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AUGUST

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MAINTENANCE ENGINEERING

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AUGUST
1932

Uses and Possibilities of Mercury Arc Rectifiers

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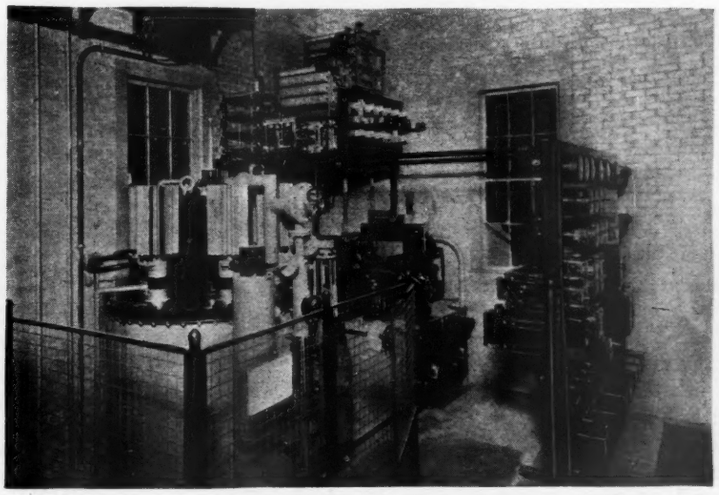


One of the original forms of mercury arc rectifier. This installation is rated 750 kw., 1,500 volts direct current.

RECENT advances have brought the reliability of mercury arc rectifiers to the point of practically trouble-free operation with little maintenance. These advances have resulted from an improved understanding of the fundamental phenomena on which the apparatus is based, and thus the gain in reliability has been accompanied by some increase in efficiency instead of by a decrease, as has usually been the case in the past. This same increase in understanding also gives promise of still further advance in efficiency and probably of ultimate cost reduction. The phenomena are extremely complex, however, and it is to be expected that further improvements will be gradual and probably slow.

Widespread adoption of mercury arc rectifiers in preference to synchronous converters in traction service has been justified partly by improved efficiency under conditions in which there is an appreciable amount of light load running, by reduction in noise where this is a controlling factor, by reduction in the cost of installation, by the greater ease in carrying away the heat of the internal losses by cooling water where sufficient circulation of air would be difficult to secure, and by other special reasons. The broad incentive, however, has been the belief that ultimately this apparatus could be brought to a stage of development in which interruptions and damage due to arcing back, or failure of the rectification function, would be so reduced that the operation would be more or less like that of a transformer, requiring only occasional maintenance attention and much less overhauling than is required for rotating equipment with commutators. Recent advances show that this hope has been well founded.

Rectifiers are peculiarly adapted to traction service because the voltage used is high enough to make efficiency and first cost comparable with those of rotating equipment, and the load conditions suit the operating characteristics of the rectifier. Occasional attempted applications in industrial fields have in general been unsatisfactory because the disadvantages, particularly in cost and efficiency, always have seemed to outweigh the advantages.

Whether recent advances in design have changed this situation depends on the comparative over-all utility of the available conversion devices, tak-

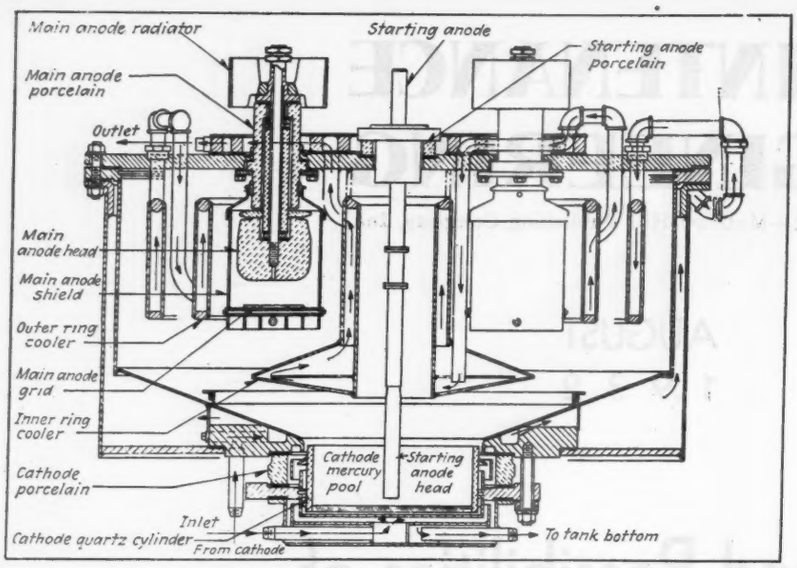


Fig. 1 — Sectional view of the latest form of rectifier in which arc-backs are reduced by control of the vapor flow. The diameter of this unit is 4 ft. 6 in., height 3 ft. 7 in. It is rated 750 kw., 600 volts.

ing all factors into account. Consideration must be given to first cost, cost of installation and spare equipment, operating cost, including internal losses, maintenance expense, and operating reliability.

For various applications these factors will be of different relative importance; thus each project becomes an individual problem. Sufficient general information will be given in this article to make it possible for users to review their own problems and determine whether a detailed study is warranted.

The mercury arc rectifier is based on the fact, first noted in 1889 by Fleming, that "an arc strikes readily at an anode and with difficulty at a cathode." In more modern terms, in an ionized gas only a small positive potential with respect to the gas is required to cause current to flow to an electrode, whereas a large negative potential can be applied before appreciable current flows. The cathode must supply electrons, which requires either a high voltage or some other initiating cause such as striking the arc by contact. The anode needs only to collect the electrons already available.

There was no promise of practical rectifying equipment until the peculiar suitability of an arc to a mercury cathode in a vacuum was realized by Peter Cooper Hewitt in 1902. An interesting laboratory phenomenon then became the operating principle of a practical device, the possibilities of which are only now commencing to be utilized.

Mercury is unusually suitable for the negative terminal or cathode at which the heat of the arc is largely concentrated, because it is liquid at ordinary temperatures. The evaporated material is not permanently removed from the cathode surface, and it does not accumulate on the inner walls of the container, destroying the insulation at the entrance bushings. Instead, it condenses and flows back to the cathode as a liquid. This continuous reconstruction of the cathode makes for permanence of the part subjected to conditions most likely to be destructive.

A further desirable characteristic of mercury is that in the form of a gas collisions of electrons with molecules are "elastic" so that current can flow with inherently low power loss. In the common gases, in which collisions are not "elastic," a large part of the energy of the electron velocity is lost in each collision, so that in general ionization by collision takes place only when the potential applied is high enough to accelerate the average electron to the ionizing velocity in a single step between collisions.

A rectifier thus consists essentially of a container from which the air has been removed and in which there are one or more solid electrodes and a single electrode of liquid mercury. A movable, auxiliary electrode is provided to strike an arc to the mercury pool, so as to initiate a cathode and produce the necessary ionization in the gas. Current then flows to the cathode readily and with small power loss from the various anodes in turn as they become sufficiently positive in potential.

Current does not flow readily in the reverse direction; that is, to the parts at negative potential. However, when the reverse potential may be quite high precautions must be taken to prevent unintentional breakdown to parts at negative potential. Besides permitting reverse current flow, which defeats the object of the rectifier, such breakdowns are destructive because there is no provision at the anodes to take care of the heat generated. These unintentional breakdowns, or arc-backs, have been the greatest barrier in the past to securing maximum benefits and best performance of mercury arc rectifiers and it is in the control of this difficulty that the recent advances lie.

A cross-section view of a rectifier is shown in Fig. 1. The arc flows from one or more of the anodes to the cathode, the number of anodes operating at one time depending on the transformer arrangement. The anodes operate in turn, current flowing from each for approximately one-third cycle with the usual transformer arrangement. The current from the cathode, which is the current in the direct-current circuit, is the sum of the anode currents.

The vapor flows out from the sur-

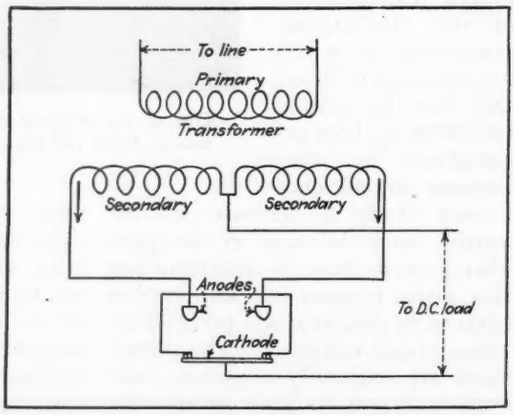


Fig. 2—Schematic diagram of usual rectifier and transformer circuits for single-phase operation. Current flow from the anodes is intermittent, first from one and then from the other. These intermittent currents are combined at the cathode, producing unidirectional current flow in the output circuit.

face of the mercury pool, being confined and directed to some extent at the beginning of its path by the guiding cylinder. The major portion of the vapor then flows through the system of ring coolers where it is condensed. The remainder passes up to the coverplate and dome and condensation is completed. The mercury vapor is permitted so far as is practicable to flow in its natural path and the condensing area for each section is made adequate for the amount of vapor. The resulting approximately smooth flow of vapor, without excessive turbulence or eddies, makes for the desired freedom from arc-backs.

In Fig. 2 is shown in simple form the usual arrangement of transformer and rectifier circuits.

The capacity of a rectifier is largely determined by the current limit. In other words, for a given current over a wide range of voltage the same rectifier will be required, whether the direct current voltage be low or high. For voltages above approximately 250 and not exceeding possibly 1,500 volts it is to be expected that a particular design will serve and that little if any advantage would be gained by making a specific design for a given voltage within that range.

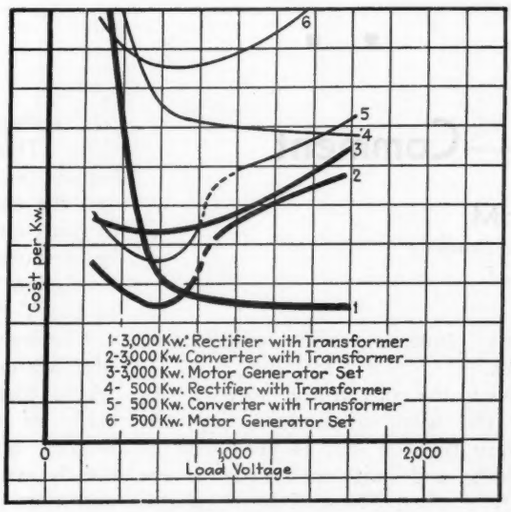

Cost per Kw.
Load Voltage
0
1,000
2,000
1- 3,000 Kw. Rectifier with Transformer
2- 3,000 Kw. Converter with Transformer
3- 3,000 Kw. Motor Generator Set
4- 500 Kw. Rectifier with Transformer
5- 500 Kw. Converter with Transformer
6- 500 Kw. Motor Generator Set

Fig. 3—Normal performance of mercury arc rectifiers under various conditions of load and voltage, with comparison of 600-volt rotary converter.

Hence, efficiency is radically affected by the operating voltage. At a given current there is a given loss within the rectifier, amounting to about 20 volts. Neglecting other factors, if the load voltage is 20, the efficiency will be 50 per cent. If the load voltage were 80, efficiency would be 80 per cent.

Likewise, the cost per kilowatt changes radically with the load voltage, because the rating changes. A 1,000-amp. device is a 600-kw. device at 600 volts, but only a 250-kw. device at 250 volts. Because the same design is required in both cases, the cost per kilowatt varies inversely as the direct-current voltage.

In present designs metal-tank rectifiers require continuous, or at least frequent, pumping to keep the density of foreign gases down to a safe value. The cost of and losses in the pumping equipment are relatively unimportant in the case of the larger rectifiers, but they become increasingly important as size is decreased. Thus, for a given output voltage the cost per kilowatt is higher and the efficiency slightly lower for the smaller capacities.

Dependence of efficiency and cost on output voltage and capacity is the predominant factor in determining the suitability of a rectifier in industrial applications. In the usual traction application the operating voltage is around 600 volts. At this voltage the full-load efficiency is about that of the usual synchronous converter. Price is somewhat higher than that of a converter.

Although both efficiency and price can be given accurately only for specific conditions, the charts in Figs. 3 and 4 give the general relation in these respects between rectifiers and several other forms of conversion equipment.

The voltage characteristics of the rectifier, on the direct-current side, depend on the characteristics and connection of the transformer. In general there is a fixed relation between the transformer secondary voltage and the delivered direct-current voltage. This is affected by the reactance of the transformer, as is to be expected. Thus the regulation curve is normally dropping and with ordinary transformer construction the drop will be around 5 per cent at full load.

Various transformer connections are available, however, and the ratio of direct-current voltage to transformer secondary voltage varies with the connection. It is possible to have the rectifier operate over a part of the load range as a three-phase device, each anode operating for one-third of the time, and over part of the range as a two-phase device, each anode operating for one-half of the time in this case.

Because the voltage delivered by the three-phase connection is higher for a given alternating-current voltage than that delivered by the two-phase connection, this expedient can be used to secure a degree of over compounding.

In general the power factor of the current taken from the alternating-current line by a rectifier is fixed at 95 to 98 per cent, depending on the transformer connections used. The wattless component is due partly to phase displacement and partly to higher harmonics. Correction is possible through the use of filters, but normally is not justified.

Inasmuch as the ratio of direct-current to alternating-current voltage is approximately fixed, to supply variable voltage or control the output voltage over some range has to be done through control of the alternating current voltage. Transformer taps, normally placed on the primary by reason of the smaller number of leads, can be used where the range is great and the number of steps need not be large. Where close control is a necessary requisite an induction regulator is used.

In considering a particular application there are a number of governing factors.

Efficiency of mercury arc rectifiers is best at the higher voltages as are size and cost. These are the major factors; in most cases one or the other of these factors will dictate the choice of some form of rotating equipment for voltages under about 500 volts. For the higher voltages the trend toward the rectifier becomes more pronounced and for the infrequent cases where voltages of 1,500 or so are required, everything seems to favor the rectifier.

In some cases other, and more subordinate, characteristics will be important. Freedom from noise, ability to use circulating water for cooling, high efficiency at light loads, freedom from vibration, reduction in the foundation requirements, reduction in maintenance expense, and some ca-

pacity for heavy, short-time loads are factors in favor of the rectifier which might be definitely controlling.

For the simplest kind of structure in which a solid anode is suspended close above a pool of mercury, and in which the vapor pressure is maintained within a reasonable value, the losses readily can be reduced to slightly below 10 volts. Losses in the present unit at full load are about 20 volts; so the possible decrease in losses would be approtimately 50 per cent.

It is safe to say that internal losses can be made somewhere between the present value of 20 volts and the probable minimum of 10 volts. As the losses are reduced it will be possible to reduce the size and cost.

Of great promise is the possibility of control through the conductivity of the gas path. In the rectifier, control can be secured in somewhat the same way as in a radio tube, except that it affects the starting of the arc only. Once the arc is started, no further control is possible. However, the ability to control the time of starting in each cycle opens the way to voltage control, operation inverted to provide alternating from direct current, frequency conversion, and regeneration.

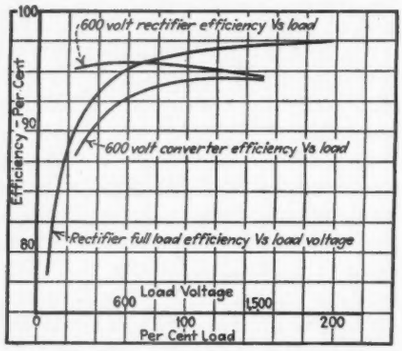


Fig. 4—How the cost of different types of conversion equipment varies with load voltage.

The possible industrial significance of such developments is difficult to measure but it is evident that if anything like the indicated possibility of improvement plus control can be realized, this device will play a predominant part in industry in the future.

■ ■

Carbon Brushes—Comment

E. C. BREHM

Engineer, Le Carbone Company
Hoboken, N. J.

THE ARTICLE by Mr. J. S. Marcus in the April issue was read by many important users of carbon brushes and it was therefore, quite fitting to publish the opinions of Mr. J. M. Zimmerman on the extremely important question, "What is the best type of slot?"

Although, as Mr. Marcus says, there are many opinions it seems to me that the answer to this question is not one of opinion but one of fact; and it is my belief that the fact has been sufficiently well established that the square-cut slot is the only right type of slot for maximum brush efficiency and minimum machine maintenance cost.

The small users of motors rarely study this question in detail or from a technical point of view. The majority are influenced by the views and experiences of others with whom they contact.

In establishments where undercutting is a real item of expense and by reason of the size of the plant a part of daily routine, definite facts have to be elicited and without exception in such cases as have come to my notice the square type of slot is adopted.

This type of slot should be no more dependent on brush material than the V-slot; on this point I fear that many users of the V-type slot do not correctly execute their undercutting work.

As to the comparative speed in doing the work of undercutting, the square type of slot is very easy to execute and quite as speedy as the V type when executed by a capable man—and no undercutting should be undertaken by any man who is not capable.

No one would think of leaving a commutator after slotting with a machine tool, if he really wanted a good job, without first cleaning out the slots. This process with the square-cut slot is extremely simple and rapid, and the ease which the dreaded fins of mica on the sides of the slots can be removed would perhaps be a revelation to many ardent followers of the V-type cutting wheel.

I believe that Mr. Zimmerman and Mr. Marcus are thinking along different lines—Mr. Marcus commercially of the user of a few small motors, and Mr. Zimmerman technically with his mind on the larger and more important users of d.c. machines, including steel mills and railroads.

My vote unquestionably is for the point of view expressed by Mr. Zimmerman, which is supported by the conclusions of organized research.

■ ■

L-Code Saves Money

L-CODE, which was introduced as a service to the electrical industry, in November, 1931, has produced excellent results in economy during its first six months in operation. Today over 300 companies of all types and sizes are using the code for from 30 per cent to 50 per cent of their normal telegraphic messages.

One large electrical manufacturing company during the last six months made a check of its telegraphic operations and found that it was able to reduce the amount of cash paid out for telegrams by 34 per cent, which amounts to $23,000. This company, like most others, is operating at reduced capacity and on this basis it has been calculated that in a normal year the savings would have been equal to $39,000 in six months.

Another electrical manufacturing company has made a saving of 28 per cent by actual analysis, which again amounts to $14,000 under present reduced operating conditions, and which under normal conditions would have equalled $27,500.

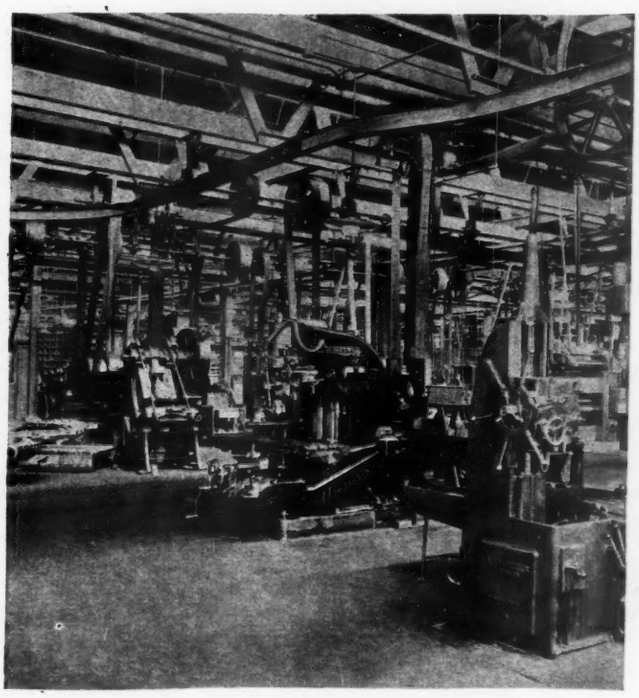
Several medium size and smaller companies have reported that 50 per cent of their messages are coded under this new industrial code, and that it is found applicable to the longer type of telegraphic messages.

INDIVIDUAL AND GROUP DRIVES

Investment and Operating Cost Data

ROBERT DRAKE

Electrical and Mechanical Engineer, Chicago, Ill.



Group drive does not necessarily interfere with overhead materials-handling equipment. In this installation of fairly heavy group driven machines chain hoists are used to move parts from machine to machine.

EFFECTS of various factors on the comparative first costs and annual costs of group and individual drives were discussed in the two preceding articles of this series. In order to show more clearly the influence of these factors I have estimated, largely from actual operating data and experience, the comparative costs and performance characteristics of group and individual drives for six characteristic types of industrial plants. The power actually delivered to the machines when the plant is operating at capacity is the same in all six plants. These comparisons are begun in this article and will be continued in the two succeeding articles of the series.

The first two plants can be considered as abnormally stable two- and three-shift plants. They are designated in the accompanying table as plants *A* and *B*. They differ only in the average power requirements of the machines installed.

These two plants, *A* and *B*, operate under conditions so favorable that they are seldom reached in American industry. In busy years or busy seasons they operate three shifts; during depressions one shift is operated. Occasionally if unsold stock piles up they shut down for a month, but whenever they operate a shift at all they operate it at capacity. On the average, over a ten-year period they operate 4,000 hours a year, which falls a trifle short of double-shift, eight-hour operation.

Each makes a single product all the year around. Nearly all machines operate continuously on a single piece part. Of course, some machines can run out the day's production in an hour or two, in which case they ordinarily stand idle the remainder of the day. On only comparatively few machines are jigs changed, except when model changes or minor changes in the product are made.

Production is so large that wherever practicable progressive dies and special jigs are used which allow the operator to unload a finished piece and insert another while the machine is working on a third piece.

Many plants manufacturing food products, chemical plants embracing considerable continuous process work, and a very few other industries would fall in this classification. Averaging in the bad years, the automobile industry hardly qualifies. It falls somewhere between this classification and the following one.

For our purpose the principal difference between these two plants lies in the fact that plant *B* contains 1,163 machines, whereas plant *A* does lighter work and contains 5,200 machines. The performance of each plant has been tabulated for both group and individual drive for comparison. In these comparisons enclosed, and enclosed, fan-cooled motors will be used in each plant for individual drive, whereas open motors will be satisfactory for group drives in the great majority of cases. Full-voltage-starting motors will be used up to 30 hp., with pushbutton starters. Above 30 hp. automatic compensators will be used. All motors and shafting hangers are assumed to have ball or roller bearings.

In plant *B* the average motor size on individual drive is approximately 7½ horsepower. In plant *A* the average motor size on individual drive is approximately 2 horsepower.

■

Comparative performance of group and individual drives for six characteristic types of industrial plants, based on actual cost data and experience. Annual power cost.

By itself a drop hammer or board hammer constitutes a highly fluctuating load. By driving them in a group the peaks and valleys can be reduced considerably and the load made fairly constant.

In plant *B* the average motor size on group drive is between 10 and 15 horsepower. In plant *A* the average motor size on group drive is between 30 and 35 horsepower.

In Fig. 6 are given further particulars as to motor sizes and speeds.

The second two plants may be considered as representing average manufacturing industry. They are designated in the tables as *C* and *D*. Like plants *A* and *B*, they differ only in the average power requirements of the installed machines. Plant *C* contains 5,800 machines and plant *D* 1,300 machines. Plants *C* and *D* normally operate a single nine-hour shift.

In normal years many departments are operated overtime and in exceptional years there is a night shift in some originating departments, such as the foundry, forge shop, and so on. The night shift is never one-third as large as the day shift, although the departments affected operate from half to full force. During the height of a depression a much-reduced day shift works a few days a week.

These plants do not operate all the year around on the same product. Some of the lines are year-around sellers, but other lines are seasonal to a great extent. Thus, at the height of a boom the whole plant never works to capacity on any one day. One department may be working overtime, whereas another department may be working at only half capacity. In boom periods operation has been at 90 per cent of plant capacity, but on the average over a ten-year period, including depressions, these plants run at 60 per cent of single-shift capacity. On the other hand, when any department is running at all it averages 86 per cent of capacity.

This is a fair picture of an average American industrial plant. It is not the most prosperous, nor by any means the least prosperous.

Enclosed motor equipment is used for individual drives; principally open-type motors for group drives, as in the case of plants *A* and *B*. In the tables it is assumed that ball and roller bearings are used in the motors and shafting hangers.

The third two plants are representative of "feast or famine" industries. They are designated in the tables as *E* and *F*. Like the preceding pairs of plants they differ only in the power requirements of the installed machines. Plant *E* contains 6,400 machines and plant *F* 1,480 machines.

Plants *E* and *F* operate ordinarily on a nine-hour basis. In busy years they may operate a full night shift in some departments. They never exceed 70 per cent of full capacity operation in all departments at once, although a number of departments may be very busy simultaneously. An average department runs an average of 50 per cent of day-shift hours, considering good years and bad.

Such operation is characteristic of seasonal industries such as vegetable and fish canning, building supplies, shoes, ladies' hats. Similarly some industries must be included such as railroad car manufacturing, that operate on huge contracts of which no great number are let in any one year, and very few in depression years. Such plants may have all the contracts that they can handle for steel freight cars, and nothing to do in the passenger coach or motor bus body departments, or *vice versa*.

Motor and mechanical transmission equipment is of the same types and average sizes described for the two preceding classes of plants.

The preceding assumptions and much of the data in Table I for plants *B, D,* and *F* are based on actual plant performance and my personal experience. Each of these three plants is patterned after an existing plant or plants, in so far as the unavoidable differences in size and other features allow. Unfortunately, I lack actual data on plants that could serve as patterns for plants *A, C,* and *E*. The comparative performance and costs for such plants were desired for the light they would give on the effect of motor size.

These latter costs are in many items built-up costs, and to that extent are less reliable than those given for plants *B, D,* and *E*. They are intended only to show roughly the relative differences as compared with plants *B, D,* and *E* doing heavier work.

It may be well to explain here some points of difference between performance figures in the table for the various plant conditions.

Referring to items 17 and 18 in the table, the power losses between the motor shaft and the machine in individual drives vary widely. Where the motors can be direct connected the loss is negligible. If a speed-reduction unit is necessary the loss is seldom less than 10 or 15 per cent; when the power is small and the reduction ratio large, the loss frequently exceeds 50 per cent. These are extreme cases. Most applications lie in a middle ground.

In Fig. 7 are shown efficiency curves recently determined under the direction of Prof. Sawdon at Cornell University for several drives suited to motors around 15- to 30-hp. capacity. There are included short belt drives with gravity idler, pivoted motor base, and rubber V-belt drives, each with bottom pull and top pull installation and presumably operating under rather favorable conditions; at least, no vertical drives are included.

The most interesting conclusion to be drawn from these curves and the

TABLE I

COMPARISON OF PERFORMANCE AND ANNUAL POWER COST OF DRIVES IN SIX TYPES OF INDUSTRIAL PLANTS

	Abnormally Stable Two- and Three-Shift Plant				Average Manufacturing Industry				Feast or Famine Industry			
	Group		*Individual*		*Group*		*Individual*		*Group*		*Individual*	
	A Many Small Drives	B Medium Drives	A Many Small Drives	B Medium Drives	C Many Small Drives	D Medium Drives	C Many Small Drives	D Medium Drives	E Many Small Drives	F Medium Drives	E Many Small Drives	F Medium Drives
Total horsepower delivered to machines												
1 If every department were operated at capacity simultaneously	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
2 With shop as busy as it ever actually operates	2,000	2,000	2,000	2,000	1,800	1,800	1,800	1,800	1,400	1,400	1,400	1,400
3 Average over ten-year period for hours when shop is running	2,000	2,000	2,000	2,000	1,200	1,200	1,200	1,200	600	600	600	600
4 Average department operates in average year, including night shift if any, hours	4,000	4,000	4,000	4,000	2,200	2,200	2,200	2,200	1,400	1,400	1,400	1,400
Motors in operation (idle motors excluded)												
5 Average full load on a 40° basis, per cent	83	91	33	40	58	64	28	33	50	55	25	28½
6 Nominal full load (some motors are rated on 55° basis), per cent	82	90	26½	32	57	63	22½	26½	49	54	20	23
7 A department runs during day shift hours average, including "bad" years, per cent	100	100	100	100	85	85	85	85	50	50	50	50
8 When a department runs days it averages capacity, per cent	100	100	100	100	70	70	70	70	60	60	60	60
9 Shop production and power delivered to machines equivalent to capacity operation (ten-year average) hours per year	4,000	4,000	4,000	4,000	1,600	1,600	1,600	1,600	800	800	800	800
10 Ratio total hp. motors, 40° basis, to output, shop at capacity	1.2	1.1	3.5	3.0	1.2	1.1	4.0	3.5	1.1	1.0	5.0	4.5
11 Ratio total hp. motors in operation at any given moment (motor hp. on 40° basis) to motor output, shop at capacity	.....	.....	3.0	2.5	.....	.....	3.66	3.0	.....	.....	4.0	3.5
12 Ratio total nominal nameplate hp. of motors installed to motor output when shop is busiest	1.22	1.11	.....	.....	1.36	1.24	.....	.....	1.6	1.46	.....	.....
13 Total connected motor load in hp. 40° rise basis	3,200	2,585	7,775	6,450	3,200	2,585	9,400	7,950	2,930	2,350	11,750	10,250
14 Total connected motor load in hp. 55° rise basis	.....	.....	9,330	7,750	.....	.....	11,300	9,540	.....	.....	14,100	12,250
15 Weighted average motor efficiency over 10 year period including reduced load operation if any, per cent	88	90	64	74	87	90	55	66	85	88	50	60
16 Weighted average motor power factor over 10 year period including reduced load operation if any, per cent	76*b*	81*c*	40*a*	45*b*	68*b*	72*c*	37*a*	40*b*	64*b*	68*c*	35*a*	35*b*
Weighted average efficiency of mechanical transmission—												
17 Shop average load, per cent	75	85	90	93	68	81	85	88	60	75	85	88
18 Shop capacity load, per cent	75	85	90	93	75	85	90	93	75	85	90	93
19 Total hp. motor output—shop operated at average activity (10-year average)	2,665	2,350	2,225	2,150	1,765	1,482	1,445	1,395	896	750	720	700
20 Input to motors in kw., 10-year aver. for hours when shop is running	2,260	1,950	2,590	2,160	1,515	1,260	1,920	1,540	880	680	1,055	885
21 During average year shop operates, including night operation (10 year average), hours	4,000	4,000	4,000	4,000	2,666	2,666	2,666	2,666	2,666	2,666	2,666	2,666
22 Electric power consumed by motors in millions of kw.-hr.	9.04	7.80	10.38	8.66	4.04	3.28	5.11	4.11	2.36	1.815	2.80	2.35
23 Cost of power per kw.-hr., average good years and bad: Demand charge cents per kw.-hr.	0.45	0.45	0.45	0.45	1.00	1.00	1.00	1.00	1.65	1.65	1.65	1.65
Energy charge cents per kw.-hr.	0.55	0.55	0.55	0.55	0.60	0.60	0.60	0.60	0.65	0.65	0.65	0.65
Total charge cents per kw.-hr.	1.00*d*	1.00*d*	1.00*d*	1.00*d*	1.60*d*	1.60*d*	1.60*d*	1.60*d*	2.30*d*	2.30*d*	2.30*d*	2.30*d*
Total cost of power used by												
24 motors per year	$90,400	$78,000	$103,800	$86,600	$64,600	$52,500	$81,900	$65,700	$54,300	$41,750	$64,300	$54,000
25 power factor correction apparatus to give 85% p.f. when shop runs	1,120	120*e*	2,200	1,930	1,100	750	1,950	1,600	900	225*e*	2,500	2,400
26 Total cost of power lost in transmission from substa. to motor term's	2,380	1,940	4,300	3,670	1,750	1,450	3,350	3,000	1,100	875	2,250	2,000
27 Annual power bill, aver. over 10 yr. period, good years and bad	$93,900	$80,060	$110,300	$92,200	$67,450	$54,700	$87,200	$70,300	$56,300	$42,850	$69,050	$58,400

a 20 per cent of machines line start motors.

b More than two-thirds of load in line start motors.

c Less than one-half of load in line start motors.

d The total electric power for the plant may be billed at a somewhat higher rate because of the inclusion of the lighting load which is a shorter hour demand and does not earn so low a rate.

e No separate synchronous condenser required. This is the additional loss of 80 per cent power factor air compressor motors as compared with unity power factor motors.

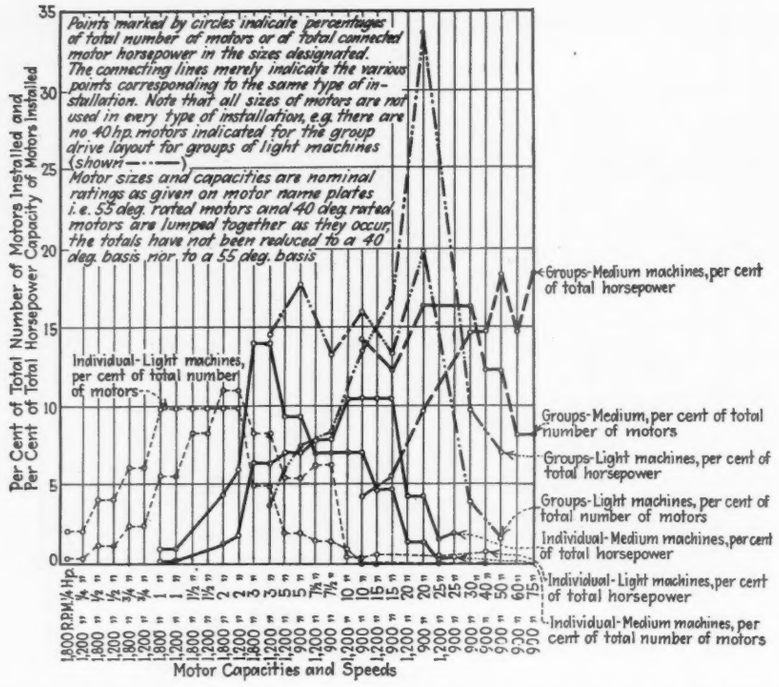

Points marked by circles indicate percentages of total number of motors or of total connected motor horsepower in the sizes designated. The connecting lines merely indicate the various points corresponding to the same type of installation. Note that all sizes of motors are not used in every type of installation, e.g. there are no 40 hp. motors indicated for the group drive layout for groups of light machines (shown ——·——·——)
Motor sizes and capacities are nominal ratings as given on motor name plates i.e. 55 deg. rated motors and 40 deg. rated motors are lumped together as they occur, the totals have not been reduced to a 40 deg. basis nor to a 55 deg. basis
Per Cent of Total Number of Motors Installed and Per Cent of Total Horsepower Capacity of Motors Installed
Individual-Light machines, per cent of total number of motors
Groups-Medium machines, per cent of total horsepower
Groups-Medium, per cent of total number of motors
Groups-Light machines, per cent of total horsepower
Groups-Light machines, per cent of total number of motors
Individual-Medium machines, per cent of total horsepower
Individual-Light machines, per cent of total horsepower
Individual-Medium machines, per cent of total number of motors
Motor Capacities and Speeds

Fig. 6—Details of motor sizes and speeds used in plants shown in Table I.

accompanying data on creep and slip is the fact that, contrary to the usual assumption, the slip loss is not nearly the total loss in the drive.

Such data are by no means general in their application, because the efficiency of each type of drive depends upon such conditions as belt speed, size of drive, belt tension, and very likely upon other variables. If the belt speed is doubled a belt only half as wide may be used, but the belt windage loss is doubled. Pulley windage loss is increased 400 to 600 per cent.

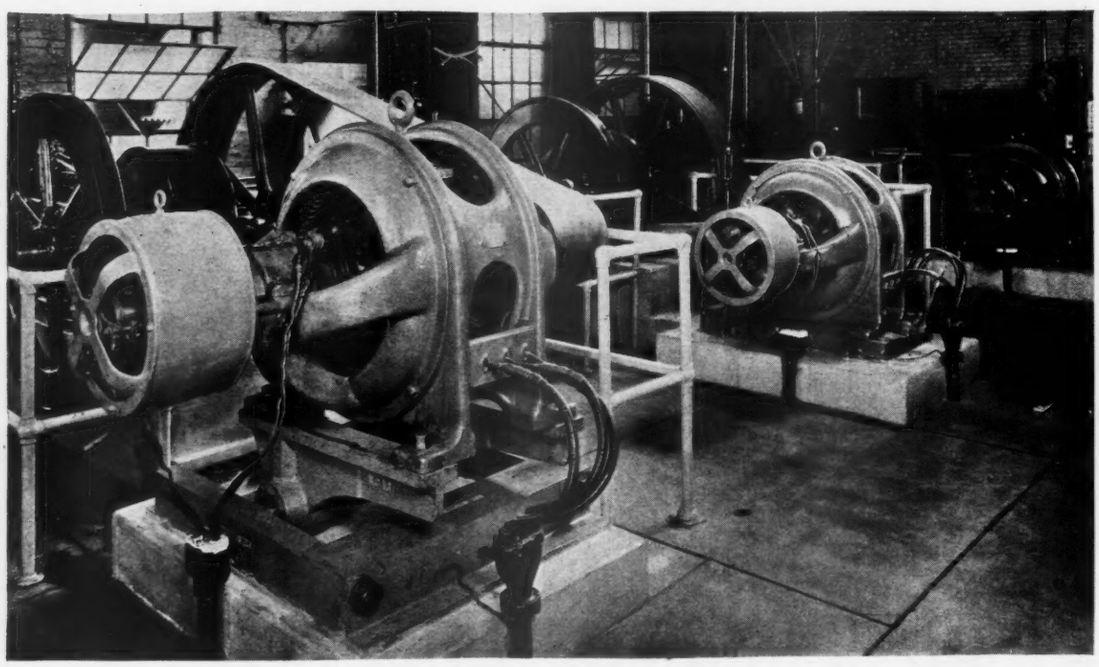
The data in Fig. 7 cover tests made at rather higher than average belt speeds in common use on individual drives. Smaller drives are ordinarily somewhat less efficient, although lower belt speeds with smaller drives may offset that tendency in some cases.

It will be noted that with full load on the driving motors a properly proportioned drive may be expected to have from 2 to 5 per cent losses in the 20- to 30-hp. range. Unfortunately, most individually driven machines operate at average loads below half of the motor rating. At such fractional loads the efficiencies are much lower.

Installation of drives decidedly larger than recommended by the manufacturer — a practice that is rather prevalent in the case of certain types lacking in overload capacity— obviously results in reduction of the efficiency of the drive under average load conditions. This fact will not, however, greatly influence the man who is convinced that the drives he is using are overrated by the supplier and that the practice in question makes for reliability and increased service. Reliability must come before efficiency.

The losses in group drives are based upon test data on complete groups, previously published by me.* Most of these data were determined by means of light-load tests to which were added the belt slip and creep

**Maintenance Engineering*, December, 1931.



Compressors, usually, lend themselves best to individual drive. Shown are one pivoted-base and two idler drives. Synchronous motors, 110 hp. each.

losses. This method gives results that are commercially accurate.

Item 10 in Table I indicates that the margin of group-drive motor capacity over the capacity load in plants *E* and *F* is less than in the plants that ordinarily operate more nearly at capacity load. This seeming anomaly is explained as follows:

The plants which I have in mind as examples of this class never operate at capacity output in all departments at once. Seasonal variations in business, such as the supply of raw materials, style changes, or lack of orders, cause some departments to be slack even in boom periods.

An "order" ordinarily covers several million dollars' worth of product. Thus, when an "order" is going through a department, it will be busy for a considerable period, whereas no orders means very little to do.

Formerly great difficulty was experienced in maintaining 60 per cent average power factor on group-drive motors, but for the past ten years it has been the practice to change such motors in accordance with the departmental activity. With no prospect of immediate activity in a department, a 50-hp. may be replaced by a 20-hp. motor. Countershaft belts are removed from all but one or two duplicate machines. Often some idle machines, useful elsewhere, are moved temporarily. Sometimes the large motor is moved to another department that is busy.

In reality, despite these expedients, if the installed motor capacity be referred to the average production or even to the actual maximum production rather than the maximum possible production a different picture is presented, as may be judged by item 12 and by the low average power factor of the group-drive motors in plants *E* and *F* (note item 16 in the table).

The annual power cost, items 23 and 24, is figured for the Central West. In the immediate vicinity of a few large cities lower costs are obtainable. In many small cities power costs are higher. The costs given should be fairly representative of favorably located medium-sized cities.

These are average costs; for example, when plants *A* and *B* are operating steadily with three or even two shifts they should earn a rate for power load well below 1 cent per kilowatt-hour. Note also that these loads do not include the cost of energy for lighting. In single-shift plants at least the average cost per kilowatt-hour of all energy as billed exceeds the cost per kilowatt-hour of the power used by motors, because the lighting load is a short-hour load much of the year.

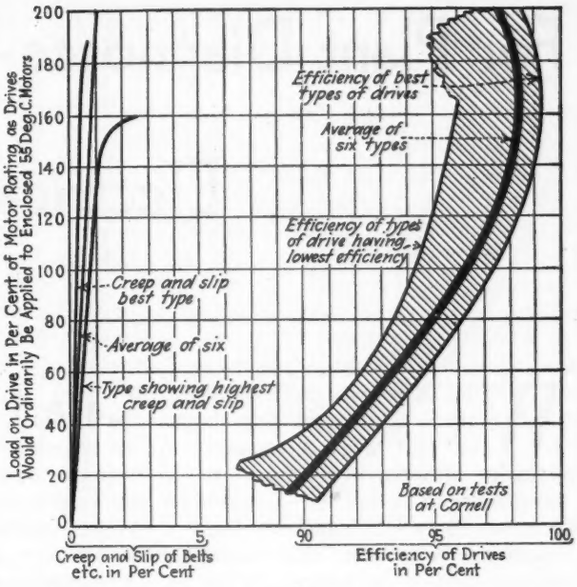
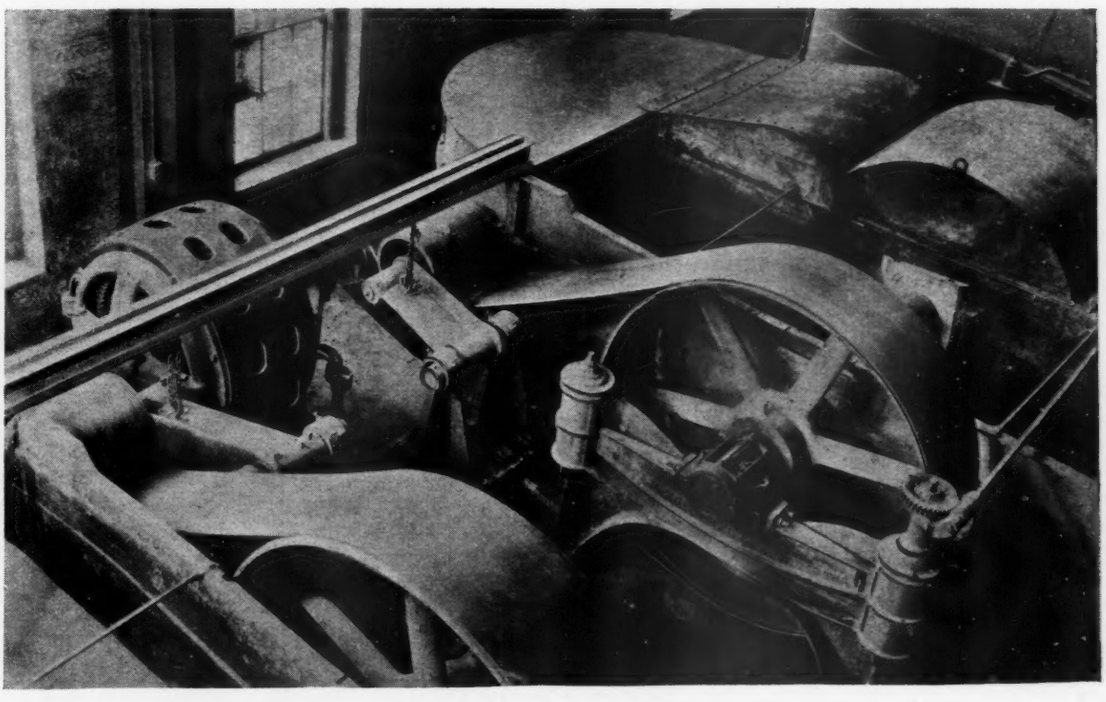


Fig. 7—Efficiency of short-center belt drives with idler, V-belt, or pivoted motor base drives, operating at belt speeds of 2,000 to 4,500 ft. per min. It will be noted that the creep and slip losses are only a small proportion of the total losses, including friction and windage.



Much paper mill equipment requires individual drive. Shown are two beaters, driven by 145-hp. motors at 500 r.p.m. Motor pulley, 18 in.; driving pulleys, 72 in.; center distance, 9 ft. 8 in.

For Plant Diagnoses—

Electrical Instruments

G. A. VAN BRUNT
Associate Editor

Electrical measuring instruments and meters are to the maintenance engineer what the clinical thermometer, the stethoscope, and the blood pressure indicator are to the physician

WHEN motors and other electrical equipment first began to find wide application in industry the chief problem was to keep them in operation. Loads were comparatively small and efficiency of operation was not the important matter that it is today. With increased power loads, more exacting requirements, more complex duty cycles, need arose for meters and instruments that would eliminate guesswork in the application and operation of equipment by revealing facts that could be discovered in no other way.

Instrument makers have done their part well; there are now available indicating and recording instruments that will enable plant engineers to determine with high accuracy any fact which may be necessary to insure the proper selection or operation of industrial electrical equipment.

Use of such meters and instruments has become widespread, but it is safe to say that many plant men have failed to realize the possibilities that these devices present in the way of determining, checking, or controlling:

1. Demand.
2. Efficiency of operation and periods of low production.
3. Continuity of operation of departments, single machines, or groups.
4. Waste of power on lighting or power systems.
5. Abnormal conditions in machines, methods, processes, or materials.
6. Proper loading of all electrical power equipment.
7. Power requirements and load characteristics of power-consuming equipment.
8. Voltage, frequency, and load on electrical supply lines and distribution systems.
9. Power costs in manufacturing operations.

A few examples will illustrate some of these possibilities:

Case 1 In a metal refining plant four mixing machines are in continuous operation. On account of overloads which damaged the stirring mechanism one of these machines was formerly out of service on an average of once every two months. The cost of repairs was usually about $500, and the delays occasioned a production loss of about 25 per cent. Such breakdowns were completely eliminated by the installation of graphic wattmeters that warn the operators when the load becomes excessive. The meter charts are filed and furnish a continuous record of the operation of this department.

These meters have also been of great service in helping the operators to keep the consistency of the mix at the proper value. If the mixture is either heavier or lighter than it should be that fact is immediately recorded as a lighter or heavier load on the motors.

2 A graphic voltmeter is mounted on the switchboard in each of the four substations in one steel plant and permanently cut into the distribution system. Whenever a ground appears on any part of the system it is at once recorded on the chart of one or more of the meters. Rapid inspection of the chart enables the operators to determine the character and severity of the ground, making it easier to detect and clear. Use of these graphic meters has resulted in a saving of 26 per cent in the delays caused by grounds. There has also been a considerable saving in the maintenance labor and materials required to keep the motors and other equipment in this steel mill in good condition.

3 A company making brass and copper wire found it desirable to increase the output of a bench drawing very heavy stock, but the possibility of overloading and burning out the 75-hp. driving motor was realized. To avoid this possibility an indicating ammeter was installed in the motor line. The maximum current which the motor could safely draw was marked in red on the ammeter and the operators were instructed not to allow the ammeter needle to pass the red mark.

Later it was found that any variations in conditions which would affect the quality of the wire were immediately reflected in the reading of the ammeter. Hence, it has been possible to maintain without effort or expense a much closer control over the quality of the product than otherwise would have been the case.

4 In order to check manufacturing operations and control the costs all electrical energy used for power or lighting in one well-known shoe plant is charged to the department or plant using it. In addition to the master kilowatt-hour meter in the main substation, each building or plant has a similar meter on its main switchboard. In many departments provision is made for metering separately the power and light consumption. With this arrangement it is possible to check the power company's monthly bill very accurately and charge each department with the exact cost of the power and light used by it.

5 Graphic instruments in an automotive engine plant showed how some large but hitherto unsuspected production losses could be reduced to almost nothing. For example, power consumption curves showed that a loss of 10 to 15 per cent was caused

by the slowness with which the men came up to full efficiency in the morning and after the noon hour, and by the slackening off before the noon hour and at night. This plant operates 800,000 man-hours a month; so a loss of 10 to 15 per cent in productive time amounted to a considerable sum of money. Measures were taken to correct these conditions, with the result that a daily loss of 91 min. was reduced to 14 min. a day.

An 18-min. loss in the morning caused by the men waiting for material and instructions was likewise reduced to 2 minutes.

Most plants can cut costs by more efficient operation of power-consuming equipment and elimination of practices or conditions that lead to waste of power and to production irregularities

6 In a Cuban sugar mill a kilowatt-hour meter is permanently connected into the circuit of a 200-hp. motor that drives a set of revolving knives for cutting up the raw material going to the mill. The ratio of kilowatt-hours to tons per hour of material cut up gives a fair indication of the condition of the knives, and shows when they should be replaced. Also, it records all idle time.

7 An instance of where electrical meters are used for definite and close control of an exacting process is found in the plant of a concern that manufactures phonograph records from plastic materials, which are thoroughly mixed in an agitator. It is very important that the mixture be of the proper consistency. It was found that the simplest way of determining this point was to place an ammeter in the circuit of the motor that drives the agitator. A glance at this meter will tell the operator whether the consistency of the material is too heavy or too light.

8 One of the large rubber companies has installed about 500 integrating watt-hour meters through the 125 departments of its main plant to measure the power consumed by the departments and many individual machines. All of these meters are read monthly and each department is charged with the power it has consumed. If the record of power consumption indicates any abnormal conditions a thorough investigation is made to locate and remedy them.

9 In a storage battery plant a large percentage of positive plates was rejected because of faulty mixing of the paste. Two inspectors would have been required to watch the seven mixing machines; so recording instruments were installed as an experiment on one mixer. The charts showed gross departures from the proper practice. When these were corrected rejections of plates were practically eliminated. Meters were installed on the remaining mixers and now serve to give closer control of the mixing process, both as to time of mixing and consistency of the ingredients, than otherwise possible.

10 Formerly much trouble was caused in a Western paper mill by breakage of the paper web between the dryers and calender of a newsprint machine composed of seven sections, each of which is driven by an individual motor. When other means failed to locate the cause of the trouble, a twin-type recording ammeter was cut into the circuits of the dryer and calender motors. Analysis of the charts obtained from this instrument showed where the trouble lay. By watching these instruments the operators can now control the motor speeds so that paper breaks have been reduced to the minimum.

11 Recording wattmeter charts from an instrument cut into the circuit of a motor driving a large power press in a metal-working shop showed 26 per cent of non-productive time out of the total hours worked. Investigation revealed that this loss of time was due to trouble with dies and waiting for stock. When these conditions were remedied the productive time of the press was brought up to an average of 95 per cent.

12 As another example of the use of graphic instruments for checking up on operating conditions, the experience of a Western flour mill may be cited. The two men employed in the bag cleaning department insisted that they were not able to do all of the required work, and needed helpers. At that time this would have meant a considerable increase in the payroll. A recording wattmeter in the motor circuit of the bag cleaning machine showed that the present operators were not busy all of the time. All talk of helpers stopped when the operators were shown how much time they had been wasting.

13 Use of a portable graphic wattmeter for occasional testing in an automotive parts plant eventually led to a thorough study of all power drives. Analysis of the results culminated in a complete revamping of the drives. The power bills were considerably reduced.

Later the practice of studying the operation of each machine on the basis of the wattmeter record was adopted and has led to important economies in the elimination of lost time and improvement in operating conditions. In one instance study of the chart given by a 20-hp. motor showed that the motor was defective, and indicated that a 10-hp. motor could carry the load.

14 In a mid-western plant the charts from a newly installed graphic wattmeter showed an occasional peak which fixed an unusually high demand for the entire month. It was then found that these peaks were caused by machines which operated intermittently being thrown on at times when the regular plant load was at a maximum. With this information at hand it was a simple matter to arrange production schedules so that certain machines were idle when the desirable maximum load was reached. In this way the demand was reduced 230 kw., at a yearly saving of $3,450, without adversely affecting plant operation.

15 In one large plant a graphic meter record from an electric furnace showed that during a 5.77-hr. heat the power was off 13 times for periods of 0.02 to 0.23 hr. each, giving a total time loss of 9.5 per cent of the entire heat. Changes that were made as a result of study of these records gave savings that are conservatively estimated at $50 a day.

16 A rubber company kept a main transformer bank on the line during the 36-hr. week-end shutdown, to supply a 2-hp. motor which operated continuously. Charts from a recording instrument showed that the week-end load, including the transformer losses, amounted to 9 kw. when the motor was running light. Substitution of a 1½-hp. motor operated from the lighting circuit, for the 2-hp. motor, and throwing the large transformers off the line over the week-end, saved 15,715 kw.-hr. consumption, or $314.30 a year.

MAINTENANCE ORDER SYSTEMS

Part VIII—Maintenance and Cost Departments Teamwork

G. I. ROSS

Chief Engineer, MacDonald Bros., Inc., Boston, Mass.

THIS is the eighth of a series of articles by Mr. Ross presenting "case studies" of various maintenance order systems.

Thus far the author has confined himself to plants of less than 1,000 employees. In this article he analyzes the maintenance problems of a plant of 2,500 employees, manufacturing metal parts and assemblies. The tie-in between the Maintenance and Cost Departments is shown.

AT A PLANT employing 2,500 people manufacturing metal parts and assemblies, a maintenance order system is used which provides a simple but thorough tie-in with the Cost Department.

Classification of Maintenance Orders—At this plant, maintenance expenditures fall under the following classifications or divisions:

(*a*) Current expense chargeable to the manufacturing departments. This is charged to departmental subaccounts.

(*b*) Current expense chargeable to some item of equipment and to some particular department. This is charged on yearly plant orders.

(*c*) Improvements to plant which will be capitalized. These are charged to individual plant orders.

(*d*) Large maintenance jobs the cost of which is to be deferred over several months. These are charged to individual plant orders.

Maintenance Order Forms—There are essentially two, viz:

(*a*) The Plant Order.
(*b*) The Sub Plant Order.

Plant Order—The Plant Order is issued for all maintenance expenditures not chargeable to a specific departmental expense account. Each one bears a distinctive number and is issued by the Plant Engineer's Office.

If the sum of the labor, material, and overhead to be expended on a plant order exceeds $100 the order

PLANT ORDER No.	DEPARTMENT	MACH. No.	Date of Order Date Completed

Department ..... will please execute the following order

Charge Acct. _____

Estimated Cost _____ Appropriation No. _____

Signed _____
Plant Engineer

Entered _____
Works Accountant

Fig. 10—Plant Order, issued for all expenditures not chargeable to a specific departmental account. Actual size, 6x4 inches.

PLANT ORDER No. A	CHARGE TO DEPT.	MACH. No.	DATE OF ORDER

Dept. _____ will execute the following order

DATE COMPLETED

CHECKED APPROVED

Material	Value	Labor	Hrs.	Value

Expense @ %

Factory Expense @ %

Total Material and Expense

Total lab. and Fact. Expense

Aggregate

Fig. 11—"A" Plant Order, obverse and reverse. This form is used when machinery is moved from one department to another. Cost data are listed on the reverse. Actual size, 6x4 inches.

must be approved first by the Plant Engineer and then by the Factory Superintendent.

If the sum of the labor, material, and overhead to be expended on a plant order exceeds $300, and the work is not strictly maintenance, an appropriation must first be secured.

The use and routine of the Plant Order form (Fig. 10) is briefly as follows:

(*a*) Prepared in triplicate by Plant Engineer's Office.

(*b*) Approved by Plant Engineer.

(*c*) Approved by Factory Superintendent.

The originals and copies of this form undergo the following routine:

(*a*) *Original*

1. Sent to Master Mechanic.
2. After completion of job, stamped 'completed" and returned to Plant Engineer's Office.
3. Filed with triplicate.

(*b*) *Duplicate*

1. Sent to Cost Department.

(*c*) *Triplicate*

1. Retained in Plant Engineer's Office.
2. Upon return of the original, withdrawn from active job file.
3. Cost obtained from Cost Department and noted on form.
4. Filed with original in "completed" file.

For the moving of machinery from one department to another, an "'A' Plant Order" (Fig. 11) is used. Space is provided on the reverse side for the listing of cost data.

Sub Plant Order—The Sub Plant Order (Fig. 12), is issued for any maintenance work chargeable to the current expense of any department. It may thus be issued by the foreman of any manufacturing department.

This type of order is issued as an authorization to perform work chargeable to yearly plant orders. It is further used as a "Sub Order" of the Plant Order. For example, a Plant Order may cover the rearrangement of an entire department, while the Sub Plant Orders under the same order number would refer only to the work to be performed by the millwrights, or electricians, and so on. This plan is of considerable assistance to the Master Mechanic.

The use and routing of the Sub Plant Order, which may be issued by any foreman, and which is prepared in triplicate, is briefly as follows:

S.O. No.	Deliver to Dept.		Mach. No.	Job No.	Date
P.O. No.	Charge To Dept.				

Department.....will please execute the following order and charge all labor and material to above Dept. and Order No.

SUB PLANT ORDER

Fig. 12—Sub Plant Order, issued for any maintenance work chargeable to the current expense of any department. Actual size, 6x4 inches.

Order No.	Deliver to Dept.		Mach. No.		Foreman	Date
Plant O.No.	Charge to Dept.		Report to			

QUANTITY	DESCRIPTION	VALUE

Delivered by	Received by
Only one item on a card	Material Delivered Card

Fig. 13—Material Requisition. This form corresponds with the Sub Plant Order in make-up, facilitating uniformity in posting data. Actual size, 6x4 inches.

DRAWING OF MACHINES

Drawing No.	Parts	Drawing No.	Parts

DATE BOUGHT	Purchase Price	Freight and Erect.	Total Cost	Purchase P.O.	Builders Mach. No.	Our Mach. No.
NAME						Spec. File No.
SIZE						Rate of Dept.
CAPACITY						Height
MAKER						Floor Space
BOUGHT OF						Weight
BELT DRIVE	Pulley Size	Pulley Speed	Max.Hp.	Average Hp.		Friction Hp.
MOTOR DRIVE	Motor No.	Motor Speed	Motor Hp.	Motor Pulley		

Building No.	Dept No.	Moved on P.O.	Date Moved	Building No.	Dept. No.	Moved on P.O.	Date Moved

Fig. 14—Machine Record Card obverse and reverse. When the new equipment has been installed, the completed cost, together with the equipment data, is posted to this form. The original and duplicate are filed, one by department number and one by machine number. Actual size, 6x4 inches.

(*a*) *Original*

1. Sent to Master Mechanic.
2. Job number* added by Master Mechanic's clerk.
3. Notation made on the form as to what group will do the work.
4. Date of receipt stamped on the form.
5. Filed in proper place on control board.
6. Upon completion of the job, sent to the timekeeper.
7. Returned by the timekeeper. Filed in Master Mechanics office.

(*b*) *Duplicate*

1. Sent to Master Machanic.

*This is done to avoid confusion which might occur if two or more jobs are done on the same charge number.

2. Removed from Control Board and handed to the man who will do the work.

3. Signed by foreman requesting the job, as evidence that the work has been satisfactorily completed.

4. Returned to Master Mechanic's Office.

(*c*) *Triplicate*

1. Retained by issuer.

Work Tickets—No individual work tickets are issued under this system. The Sub Plant Order serves as the work order to the foreman of each maintenance department. He distributes his men as he sees fit. The timekeeper prepares individual time tickets showing the job number, the man number, and the elapsed time. These are later used in the compilation of the daily time sheet.

Material Requisitions—Any maintenance man requiring material or supplies must apply to the Master Mechanic's clerk for a material requisition. Fig. 13 shows this form.

It will be noted that this form corresponds somewhat with the Sub Plant Order in make-up, thus facilitating uniformity in posting data.

Machine Record Card—This plant has wisely tied in its machine records with the maintenance order system.

In the case of new equipment, a Machine Record Card (Fig. 14) is prepared in duplicate at the time the requisition for purchase and plant order for installation are issued. These cards are held in suspense until the new piece of equipment is received. When the equipment has been installed, the completed cost, as reported by the Cost Department, together with the equipment data, is posted to this form. The original and duplicate are filed, one by department number and one by machine number.

Maintenance Costs—Each day the timekeeper submits a labor cost report showing the cost expended for each person against each job number and allocating this cost to the appropriate charge number. This information together with the data contained on the Sub Plant Orders is transferred to tabulating cards, which are filed. It is then a simple matter to sort the cards and obtain maintenance costs for any period and according to practically any breakdown.

Each month the plant Engineer is furnished with a report of completed plant orders, showing the cost, both estimated and actual.

Appropriations—The management requires that any work, not strictly chargeable to maintenance, and which is estimated to cost more than $300, be covered by an appropriation. This must be approved by the President and the Works Manager.

In order to obtain an appropriation it is necessary to prepare a detailed estimate, and to submit this with a memorandum stating why the expenditure should be made, and what savings, if any, will result.

How "cost consciousness" in regard to the maintenance work in a plant of 6,000 employees is stimulated, will be discussed next month.

■ ■

PROFIT PAINTING

"BY GOLLY—dot machine run better now." A freshly painted machine tool was referred to by its operator. Run better. It didn't—but the operator thought it did, and thought more of his job, and something important had been gained.

Said management: "The general effect throughout the newly painted shop has been one of increased morale shown by the men who unconsciously take greater pride in their personal appearance, and have expressed their appreciation of working under brighter, cleaner surroundings. Increased lighting effect has permitted greatly reduced use of current for lighting purposes."

The scene of this painting activity was the Buffalo Works of the Worthington Pump and Machinery Corporation. Here is how extensive the job was:

Walls and ceilings of the shops were sprayed with aluminum paint. Pipe lines were given distinctive color coats (see accompanying table). Overhead traveling cranes were lettered with messages such as "Prevent Accidents," "Act Safely," "Return Tools." Jib cranes were painted with alternate diagonal stripes of orange and black. Machine tools were painted a glossy battleship gray, touched off in brilliant carmine. Aisles were defined by white lines.

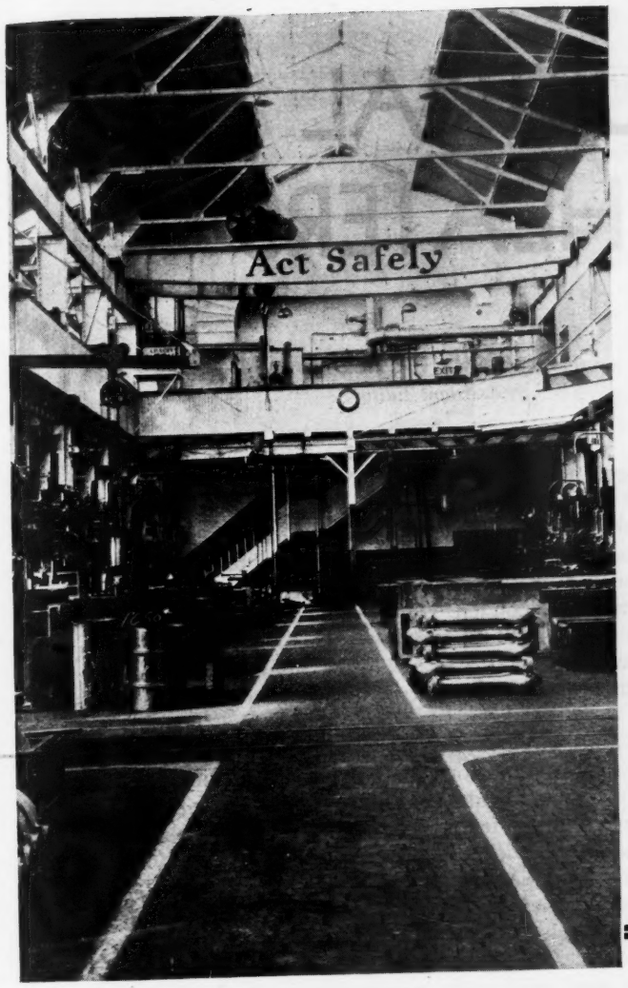
And the procedure in selecting paint: Aluminum paint was recommended by paint manufacturers as to wearing qualities and lighting values.

Samples of aluminum vehicles were obtained and tested—by weathering, by burning, and by application. Weathering is an obvious test. Burning, done by means of a blow torch, indicated great differences among vehicles. Application checked up on the covering qualities, important as affecting the economy of the job.

The vehicle and powder were purchased separately and mixed in quantities of a day's supply at a time. Amounts were carefully weighed to secure uniformity. All surfaces to be painted were cleaned thoroughly by means of wire brushes and compressed air.

PIPE LINE COLOR CODE

Steam, high pressure	Aluminum
Steam, low pressure	Buff
Water, mill supply	Green
Water, hot supply	Green with white trim
Water, drains to sewers	Dark green
Air, low pressure	Royal blue
Air, high pressure	Blue with white fittings
Oil, fuel	Black with red fittings
Oil, lubricating	Yellow
Electric conduits or fittings	Black
Sprinkler piping	Fireman red
Gas	Black with white fittings
Water returns from heating systems	Aluminum with green fittings


Act Safely

PREVENT ACCIDENTS

Return Tools
CAPACITY
20 TONS
Prevent Accidents

INDUSTRIAL UNIT HEATERS

CARL HEYEL
Assistant Editor

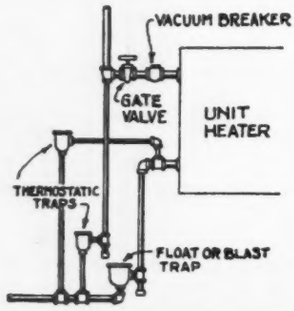


Fig. 9—Vacuum system connections for suspended type unit heater. The return is fitted with a large capacity trap to discharge the water of condensation and with a separate thermostatic valve for eliminating the air.

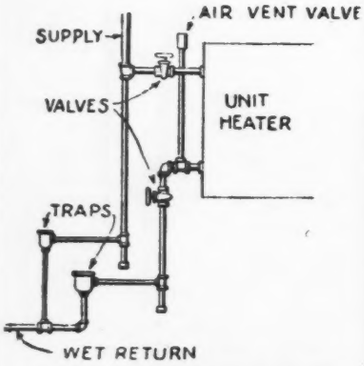


Fig. 10 — Two-pipe, low-pressure, gravity, closed system connections for suspended type unit heater. The return is fitted with a heavy-duty blast trap.

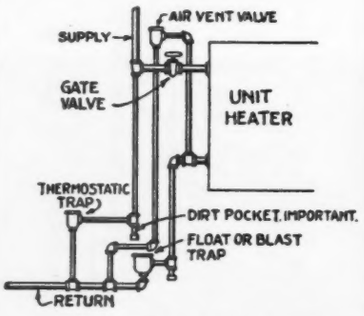


Fig. 11 — Two-pipe, low-pressure, gravity; open system connections for suspended type unit heater.

BY FAR the greatest application of unit heaters is with low-pressure steam systems. Although most manufacturers give ratings ranging from 2 to 150 lb. per sq.in., the lower pressures are recommended for their reduced piping and trap troubles, unless the availability of process steam makes the use of higher pressures of greater economy.

Pressures below 5 lb. can be used for recirculating unit heaters when their coils are designed for the purpose and when proper provisions are made for returning the condensate. Not less than 5 lb. should be maintained on the heater coils if air is taken in at a temperature below freezing.

One-pipe gravity and vapor systems are not very satisfactory for unit heaters because of the difficulty in returning the water resulting from the high rate of condensation in the coils. Under extreme conditions of low entering air temperatures, this condensate may be as much as 5 lb. per hour.

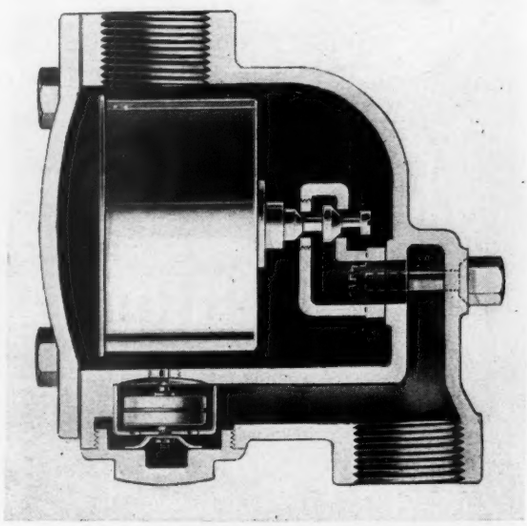
Systems commonly used with unit heaters are low-pressure vacuum; two-pipe, low-pressure, gravity, closed; and two-pipe, low-pressure, gravity open systems. Theoretically they are on a par as far as heating efficiency is concerned, the choice of a particular system usually hinging among other factors upon the closeness of steam control desired. The vacuum return system allows units to be located below the level of the return main or below the water level in the boiler. In vacuum systems, for which the heater connections are illustrated in Fig. 9, the condensate and air are removed by means of a vacuum pump.

Figure 10 shows the usual two-pipe, low-pressure, gravity, closed system connections. There is a definite steam pressure in the return main which, together with the static head between the return main and the boiler water line, returns the condensate to the boiler.

The two-pipe, low-pressure, gravity, open system connections are shown in Fig. 11. There is no pressure maintained in the return main, the condensate flowing by gravity to pump and receiver, or hot well, and discharging to boiler by mechanical means.

In these three illustrations the connection shown joining the supply header with the return header through a thermostatic trap drains the condensate from the supply line directly into the return pipe.

Connections for the recirculating



Courtesy of Hoffman Specialty Company.

Fig. 12—Float and thermostatic trap. Initial and entrained air is vented above the water line directly to the returns through a separate passage controlled by the sensitive thermal member.

The first article of this series appeared in the July issue.

floor box type heater are similar to those for the suspended units.

Unit heater ratings will be discussed more fully later, when the A.S.H.V.E. "Standard Code for Testing and Rating Steam Unit Heaters" will be described. However, it may be well to mention here that in practice unit heaters are rated in terms of B.t.u. per hr. at a given temperature of air entering the heater, and at a given steam pressure maintained on the coil. The Code fixes 2 lb. and 60 deg. F. as a basis of rating. A common, although not so precise, indication of the capacity of a heater is its equivalent square feet of direct radiation, assuming that an ordinary cast-iron radiator gives about 240 B.t.u. per hr. at 2-lb. pressure.

Maximum heat delivery by unit heaters depends largely upon the effective use of the steam space. Much therefore depends upon the traps used in the piping connections. To obtain the best results condensate must be discharged as soon as it forms.

In these steam traps two main principles are used. The *float trap* employs a hollow float which rises as water enters, and by means of levers opens a valve and permits the water to be discharged. In the bucket type a bucket fills as the water enters, and sinks, opening the valve. The bucket trap discharges intermittently; the float trap discharges more or less continuously.

There are several types of *thermostatic traps* on the market. They usually contain a thin-walled metal chamber, or bellows, filled with a volatile liquid such as alcohol. Air and condensate are permitted to pass, but the high-temperature steam causes the liquid to volatilize, expanding the bellows and consequently closing the valve seat.

A combination of the float and volatile liquid chamber is incorporated also in the common air valves.

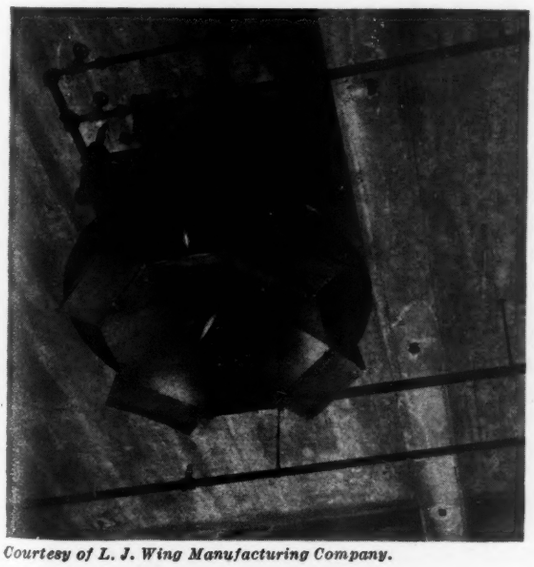
These principles are illustrated in Fig. 12, which shows a cross-section of a trap used for dripping risers, steam mains, unit heaters, and other apparatus where a cooling leg is not practical or desirable.

Fans

Fans and motors are, of course, integral parts of unit heaters and are designed by the manufacturer to meet the requirements of his product. The location of the fan behind or in front of the heating element serves further to classify a unit heater as a "blow-through" or a "draw-through" type.

Suspended units—Suspended-type unit heaters are for the most part blow-through types. Almost invariably they employ disk or propeller fans, which are low in first cost, economical in operation, and can handle considerable quantities of air against low pressures—i.e., against the comparatively small resistance to air flow offered by the heating elements in the absence of duct work or extensive inclosures.

Theoretically, the draw-through unit offers some advantages over the blow-through in that it more nearly utilizes all of the heating surface; opposed is the objection, on the part of some engineers, to placing the driving motor in the hot air stream. In Fig. 13 is illustrated a draw-through unit with steam connections plainly shown.



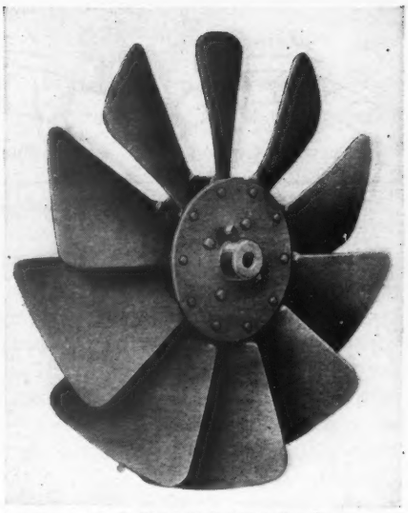
Courtesy of L. J. Wing Manufacturing Company.

Fig. 13—Installation picture of suspended draw-through unit, showing steam connections.

Typical disk and propeller fans are shown in Figs. 14 and 15. The distinguishing feature of the propeller fan, clearly shown in the illustration, is the variation in the blade pitch.

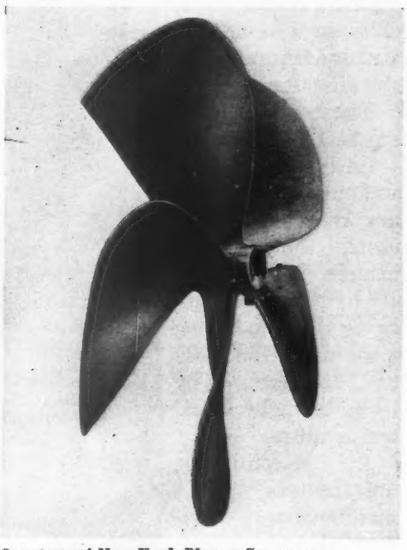
Much research work has gone into fan design in recent years, and most manufacturers have a distinctive development as regards blade pitch, curvature, hub, speed, and the like, for which they claim individual points of superiority. It may be said, however, that one inherent weakness of propeller and disk fans has not yet been quite overcome: their tendency, when operating against even a slight resistance, to allow the air to swirl backward toward the center because of the lower tangential velocity of the parts of the blades near the hub as compared with their peripheral speed. Thus the driving power required increases rapidly with increasing resistance, and the noise at such times is often objectionable.

This condition has limited the use of suspended-type heaters to much lower air velocities than can be used



Courtesy of L. J. Wing Manufacturing Co.

Fig. 14—Example of disk fan.



Courtesy of New York Blower Company.

Fig. 15—Example of propeller fan.

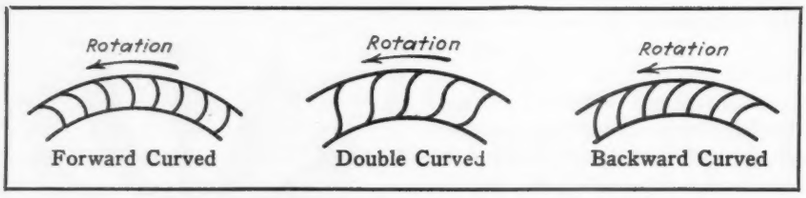


Fig. 17—Examples of blade design for centrifugal blowers.

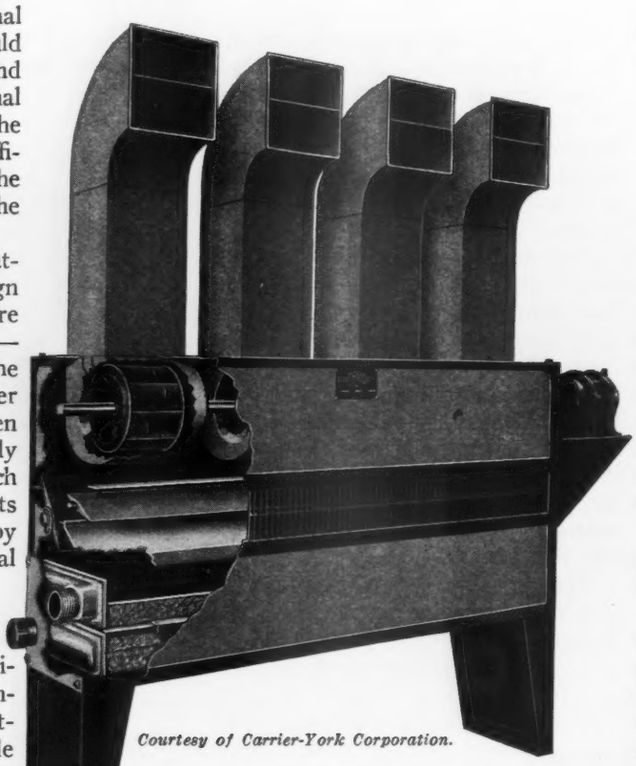
in recirculating units using centrifugal blowers, 700 ft. per min. being considered an average output velocity for the former. Therefore the B.t.u. ratings of suspended units are small as compared with the outputs of recirculating types. To obtain comparable outputs much higher final temperatures would have to be used; and the higher this final temperature is, the greater is the difficulty in forcing the air down upon the working zone.

These compensating factors of design —final temperature and output velocity— are reflected in the costs, the cheaper heaters of a given B.t.u. rating usually being those in which a saving in fan costs has been procured by using a higher final temperature.

In selecting unit heaters the maintenance engineer should remember that B.t.u. output is not the sole criterion of results. As between two units of the same B.t.u. rating, the one with the lower final temperature is generally to be considered the better choice. Its advantages are cumulative; not only has the blast of air less tendency to rise, but the fan design permits air to be forced downward with greater velocity.

Floor units—Although some floor box recirculating heaters use disk or propeller fans and are, in fact, merely suspended type units on a pedestal with a short duct extended to the floor, most floor units use centrifugal blowers, as illustrated in Fig. 16, to obtain greater velocities and pressures. These blowers take in the air axially and discharge it radially

As with propeller and disk fans, centrifugal blowers are available with a variety of blade designs. For unit heater work, three types, as illustrated in Fig. 17, are commonly used: forward curved, backward curved, and double curved blades.



Courtesy of Carrier-York Corporation.

Fig. 16—Use of centrifugal blower to obtain desirable velocity and pressure. The air is taken in axially and discharged radially.

While the maintenance engineer need not master all of the details of fan design, there are some broad principles concerning blowers which should aid him in a choice for a specific installation. He should remember that (1) blowers are to be used where pressures are to be overcome, or high output velocities required; (2) if the outlet of a blower is partially closed off, the horsepower required decreases, i.e., the horsepower decreases with the "per cent of wide open volume," so that if outlet dampers or louvers are accidentally shut, there is no danger of burning out the driving motor; (3) for a given delivery, the forward curved type operates at the lowest, the full backward at the highest, and the double curved at an intermediate speed; (4) the last two named types are best for installations where operation will be against widely fluctuating pressures.

The concluding article of this series will outline the procedure usually followed by plant engineers or representatives of heater manufacturers in determining what type of installation a given plant requires, the size of the heaters needed, and location of the various units for best results. The common methods of regulating the steam input and controlling the heat output will also be touched upon.

■

Industrial Plants Reduce Accidents

DURING the past two years 4,000 industrial members of the National Safety Council have reduced their accident frequency rate 39 per cent. As industrial frequency rates are established in accordance with the number of man-hours worked it can be seen that the economic problem had nothing to do with this remarkable achievement.

These concerns represent 28 separate industries, or practically all industrial lines.

There were 17,000 industrial fatalities in the country during 1931, according to "Accident Facts" published by the National Safety Council. Approximately 3,000 of these occurred in manufacturing plants. The others occurred in mines, railroads, construction work, marine operations, farms and other fields not definitely ordinary manufacturing.

The handling of objects, use of machinery, falls and falling objects were leading industrial accident causes. Resulting cuts and lacerations constituted about 30 per cent of all of the industrial accidents.

■

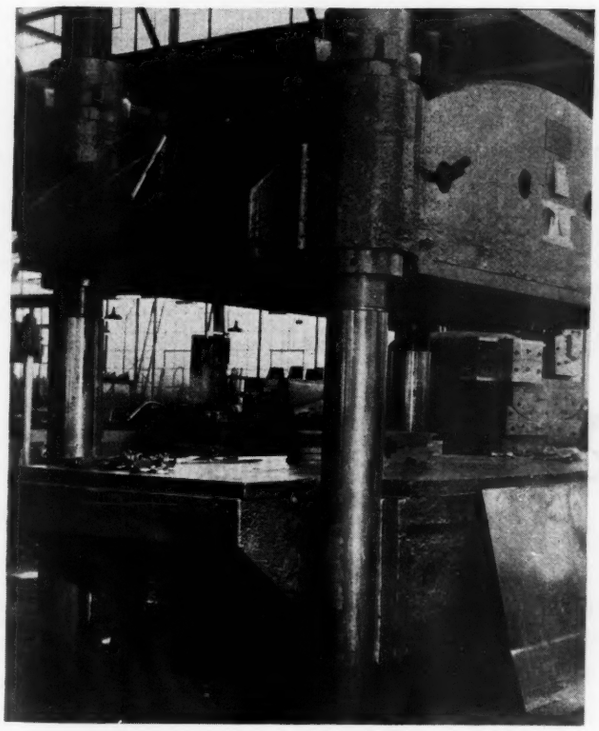
Welders Tested

REALIZING the necessity for surrounding welding with every possible safeguard, the Welding Contractors Association of New York, Inc., now requires that its company members have their welders qualified by test.

MAINT-O-GRAPHS

Ways of increasing efficiency of equipment ◆ Ideas that will help plant men
News of books and events ◆ ◆ Practical solutions of plant problems
Unusual developments in apparatus design

CONTRIBUTIONS ARE WELCOME



Blowpipe Used in Rebabbiting Bearings

SOURCE: Linde Air Products Company

Bearings of a large forming press were rebabbitted in place. The press was lined up by blocks, and one bearing at a time was worked on. Due to the shape and the length of the bearings it was necessary to get in behind the guide pillars with the welding blowpipe. A blowpipe with a long heating head was used which permitted the welder to carry the oxy-acetylene flame to any point of the babbitt bearing by bending the heating head. In this way the old metal was melted out.

While the shafts and the bearings were still hot, a clay mold was built around the outer half of each shaft and across to each side of the bearings so that a mold was formed into which the new babbitt was poured around the shaft. All four bearings were rebabbitted in less than a day.

Free Employment Service

The Engineers' Club of Philadelphia, supported by twelve affiliated engineering societies, has organized the Philadelphia Technical Service Committee to assist the employer of technical talent and the unemployed engineer.

Facilities are available without cost to employee or employer. The address of the committee is Engineers' Club, 1317 Spruce Street.

A New Protected Metal

SOURCE: Mellon Institute, Pittsburgh, Pa.

"Robertson-Bonded Metal" (R-B-M) has been carried through the laboratory stages of development at Mellon Institute of Industrial Research. This metal consists of a laminated metal-felt material in which felted materials are cemented to steel with heat and pressure, utilizing metals as adhesives.

The composite laminated material, the outer surfaces of which are suitable felts, is saturated with any desired saturant chosen with reference to the corrosive condition to which the metal is to be exposed in service. Paint, lacquer and resin films superimposed on the saturated felt give not only added protection, but also desired attractiveness of appearance in the finished product.

The ductile nature of the metal bond between felt and steel makes it possible to subject this material to forming operations such as shearing, bending, corrugating, rolling and mild drawing without destroying adhesion between felt and steel.

By selecting asbestos felt together with fireproof saturant a fireproof material results, while an increased insulating value over that of bare metal is obtained with

any combination of felt and saturants. It is also claimed that this new material of construction has the strength of metal with none of the attendant "ring" and reverberation of bare metal.

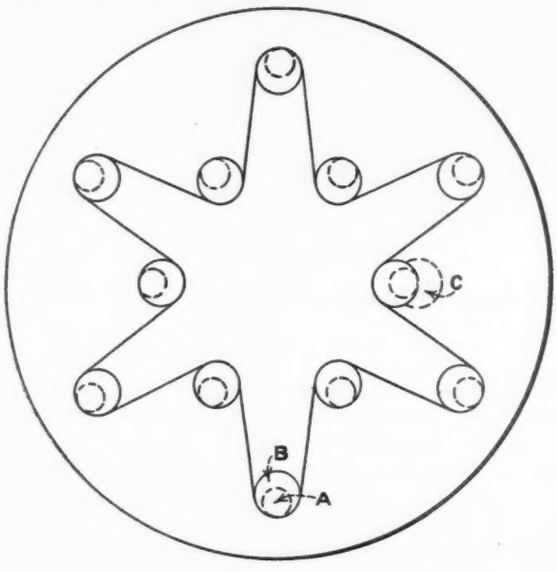
Standard Specifications, Railings and Toe Boards

The first national standard specifications for the construction of railings and toe boards have just been approved by the American Standards Association as a part of the Safety Code for Floor and Wall Openings, Railings, and Toe Boards (A12). This new safety code applies to all places where there is a hazard of persons or materials falling through floor or wall openings, or from stairways and runways. American Standards Association, 29 W. 39th St., New York, N. Y. 20 cents.

Flexible Coupling Maintenance Simplified

JOHN E. HYLER, Peoria, Ill.

In your June issue F. E. Gooding set forth a method of altering the type of flexible coupling with a short endless belt laced among twelve pins, six on each plate. While his method is good in a great many cases, it does



have the objection which Mr. Gooding himself pointed out.

Shown herewith is a method which I like a great deal better, since it permits one to retain the coupling as a safety link when desired, and also makes the takeup of stretch in the belt a very simple matter. Instead of making the pins straight or plain shouldered, make them eccentric. Thread the ends that are to go through the plate to receive nuts and lock washers. Slack developing in the belt may be taken up simply by loosening one or more of the eccentric pins, turning them in their seats, and tightening.

In the drawing the dotted line at *A* indicates the threaded portion, and *B* indicates the larger part of the pin upon which the belt is held. At *C* is shown an approximate location of the adjacent pin, were it to be turned through 180 deg. As shown, all pins in the inner circle have been tightened, those in the outer circle still are to be tightened.

Where high speed is not involved, it makes little difference as to which pins are adjusted. But where the speed of the coupling is high, adjustment must be made in a pair of pins which are diametrically opposite upon the plate, in order to keep the balance correct. The small ends of the pins may be marked with a file, when they are installed, to show the point of common tangency. This will prove to be an aid in adjusting a pair of pins equally.

General Engineering Handbook

Broad coverage of the engineering field characterizes this new handbook, edited by Charles Edward O'Rourke, Assistant Professor of Structural Engineering, Cornell University, and a group of specialist associates.

In the "general" sections are given instructions concerning mathematics, mathematical tables, data on materials, mechanics, and hydraulics.

In the sections devoted to civil, mechanical, and electrical engineering are given compact reference data concerning fundamentals of those branches.

The book obviously will be of great service to the general engineer. It should also well serve the specialist because of its content of data concerning the other branches of engineering supplementary to his specialty.

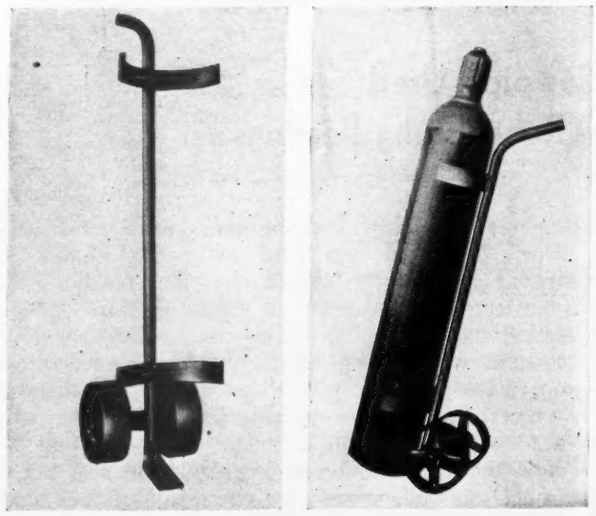
McGraw-Hill Book Company, 330 W. 42d St., New York, N. Y. $4.

Gas Cylinder Hand Truck

W. C. SUTTON, Plant Engineer
The Lindsay Wire Weaving Company

To move standard high-pressure gas cylinders, the truck illustrated is light and strong, is readily handled, and is a real convenience, especially in small spaces.

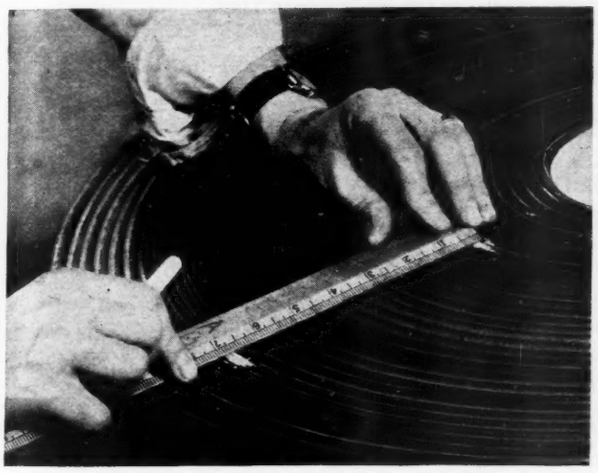
Specifications: frame, 1-in. steel pipe 56 in. long, with



one end bent after flattening to slip under a cylinder, and the other end bent to form a handle; axle, 1-in. pipe, 12 in. long, with ends turned to 1¼ in. to fit the two 8x3-in. iron pulleys used as wheels; wheels located by washers with cotter pins through the axle; axle welded to a short piece of 1¼-in. pipe which serves to space the wheels to clear the cylinder; spacer welded to frame; cylinder cradle arms ½x2-in. steel bent to shape and welded to frame. (The arms could well be lighter, say ⅜x1½ inches.)

How to Measure Thickness of Leather Belting

Leather belting is now sold by thickness instead of weight (*M.E.*, April, 1932, p. 180). To determine thickness, measure the total thickness of twenty turns and divide by 20.



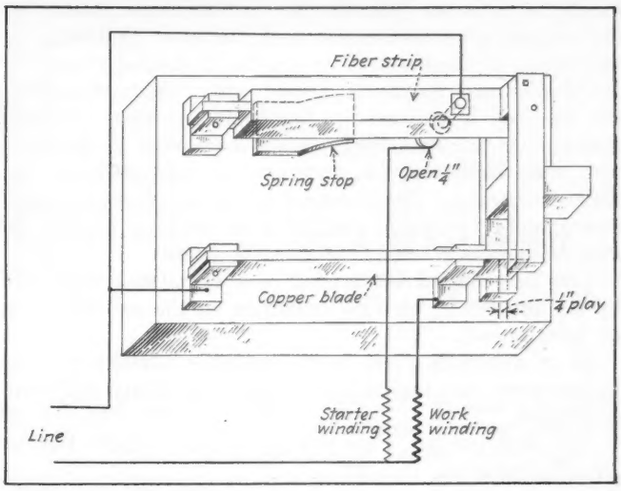
Manually Operated Switch Saves Rewinding Motor

E. Molinet, Electrical Engineer
The Cuban-American Sugar Company

In "Around the Works" of February, 1932, Mr. Chas. A. Peterson gives, as a remedy for trouble in the centrifugal switch of single-phase motors, the rewinding of the motors for three-phase operation.

When three-phase is not available, a manually operated switch is suitable, and is cheaper than replacing the entire winding or repairing the centrifugal switch. This manually operated switch is made as follows:

Take a double-pole, single-throw, knife switch of suitable rating for the motor. Replace one of the knife blades with a strip of fiber, and remove the contact jaw for this blade. Mount a contact on the fiber strip and one where the jaw was, so that when the switch is closed these two contacts touch. Prepare the insulating piece joining the two blades of the switch so that it is firmly held on the fiber strip and so that there is about ¼ in. play between it and the copper blade when the switch handle is operated. Mount a spring stop on the switch



base so that when the switch is closed the contact mounted on the fiber blade and its mate open ¼ in. as soon as the pressure of the hand is released, while the copper blade remains in the contact jaw. The switch connects the running winding to the line through the blade contacts, and the starting winding through the newly mounted contacts; but as soon as the motor is up to speed the pressure of the hand is released and the starting contacts open ¼ in., disconnecting the starting winding and leaving the running winding connected through the blade contacts.

The A.S.H.V.E. Guide, 1932

The 10th edition of The A.S.H.V.E. Guide, 1932, published by the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York, N. Y., is now available. There are four major sections, the text section, the manufacturers' catalog data section, the index to modern equipment, and the membership roll of the Society.

The text section contains 40 chapters of data on the design and installation of heating, ventilating, and air conditioning systems, and represents a complete revision. Definitions and abbreviations are given in the first chapter.

In the appended catalog data section, comprising about half of the entire book, is contained supplementary information on specific materials, equipment, and accessories available for heating and ventilating service. In it will be found sizes, shapes, capacities, dimensions, space requirements, etc. It has 956 pages, and is priced at $5.

Fundamentals of Instrumentation

A distinct service to the cause of greater efficiency in process work, through more precise measurement and better control of conditions, has been rendered by M. F. Behar in the preparation of this volume. It is the first of a series of handbooks on the measurement and control of such conditions as temperature, humidity, pressure, and so on.

The present volume is not so much a treatise on instru-

ments as it is an introduction to "instrumentation"—the science of measurement and control. Following a discussion of the value of control in industrial processes definitions are given of terms and classifications of the uses of instruments. The elements that compose instruments are described, with a discussion of the factors that influence the accuracy of measurement by different means. Performance of the more complicated instruments by which control over various conditions may be obtained is treated in some detail.

The last chapter is devoted to a valuable symposium by six authors in various industries on the use and care of instruments.

In an appendix there is an extensive bibliography on instruments and methods of measuring many different quantities.

The Instruments Publishing Company, 3619 Forbes St., Philadelphia, Pa., $2.

■

National Electrical Code Handbook

Designed to enable the reader to grasp the general plan, scope, and intent of the National Electrical Code requirements and to make practical applications of the rules clear and easily understandable, this book by Arthur L. Abbott will be found a helpful reference source to all code users and will also serve as a textbook for those making a systematic study of the code.

Provisions of the Code are divided into five parts:

Part I. Definitions of the terms used in the Code. These naturally should precede the rules themselves.

Part II. Rules specifying what types of wiring are approved under given conditions.

Part III. Materials and apparatus. This division includes requirements pertaining to standard materials and apparatus and to the standard methods of installing such materials and apparatus.

Part IV. General requirements applying to all wiring systems.

The Publisher is the McGraw-Hill Book Company, Inc., 330 West 42nd St., New York, N. Y. Price $3.

■

Driving of Conveyor Idlers Open to These Objections

SOURCE: Stephens-Adamson Mfg. Co.

A recent "Maint-o-Graph" contributor (M.E., June, 1932, p. 261) suggested that conveyor belt tension could be reduced (with a resulting increase in belt life) by *driving* some of the intermediate belt idlers or carriers in addition to the usual head end drive.

There are several objections which might make the system impracticable for use on the high-capacity, troughed belt conveyors used in this country.

Take, for example, a 30-in. conveyor belt handling crushed stone and with carriers spaced at 4-ft. intervals. The total weight of load and belt resting on one carrier would be approximately 220 lb. With a liberal (0.25) coefficient of friction between roller and belt, the maximum belt pull that could be given by one driven carrier would be 55 lb. At normal conveyor speed this would average about ½ horsepower.

Thus, to relieve the head end drive of 5 hp., at least ten carriers would have to be driven. These ten carriers would cover a space of about 40 ft. and would present an expensive drive problem—especially if three-roller troughing carriers were used. To be of any real value, the driven carriers would have to be located at some distance from the main drive, which probably would necessitate a separate drive motor and interlocking switches.

After comparing the cost with the advantages, it would seem that the saving in belt wear and tear would hardly justify the cost of an intermediate carrier drive. The average belt conveyor operator might better spend his money for the best anti-friction carriers, spaced closely enough to minimize the retroughing action that takes so much power.

Well designed carriers, with rollers turning on ball or roller bearings, will reduce belt tension and the power required to start and to run horizontal conveyors by 20 per cent to 30 per cent. If properly built, the rollers are spaced closely enough to prevent pinching or cracking belts, and the better grade carriers will train the belt to run true without guide rollers, which are so likely to wear belt edges to the point where moisture can enter and weaken the binder between plies.

■

Electric Truck Serves as Conveyor Deflector

ALFRED MELGARD, Mishawaka, Ind.

A perplexing problem in the design of the conveying system for a large Texas oil refinery was to distribute oil-filled drums equally from an apron conveyor onto a large number of gravity roller conveyor storage lines, spaced side by side as shown. The problem was solved by means of a special electric truck fitted with a deflecting arm. The truck operates on track parallel to the apron conveyor and can deflect the drums onto any desired storage line.

QUESTIONS and ANSWERS

Conducted by
G. A. VAN BRUNT
Associate Editor

Please submit answers promptly. We expect to publish no answers later than the second issue after the appearance of the question. Selection will be made on the basis of quality, but answers first received have the best chance of being used

■

Operating D.C. Portable Drills on A.C.

We wish to operate two portable electric drills rated 250 and 230 volts d.c. on 220-volt, 60-cycle, single-phase current. Under the impression that any series motor would run satisfactorily on single-phase a.c. if the voltages were about the same, both drills were tried out. Although they ran at about the proper speed they immediately became hot and there was a considerable amount of sparking at the brushes. It appears to me that the size of wire in the windings is too small for the voltage. I wish someone would tell me (*a*) whether there is any way to make them operate satisfactorily without rewinding; (*b*) if necessary to rewind would it be economical to do so; (*c*) what size of wire should be used.

Mountain Park, Alta., Canada G. N.

Globe or Gate Valve?

The question often arises as to whether a globe or a gate valve should be used on a line handling steam, water, or other liquids under low or medium pressure. Often the question is settled by putting in whichever we happen to have on hand, but I am not sure that this procedure gives us what we really need. I wish that readers would tell me the conditions under which they use globe and gate valves, respectively, and why. What are the particular advantages of each?

Buffalo, N. Y. **L.W.W.**

Preventing Rise in Voltage on Power Lines

Our lighting circuits are fed from the 220-volt, three-phase power lines. At times just as we cut off the power from our motors the voltage will jump to 260 or 270; hence, we are forced to use 135-volt lamps in order to avoid frequent burnouts. Does this excessive rise in voltage indicate any defects in the power company's equipment, or does the fault lie in our plant?

Springfield, Mo. **W. L.**

LIGHTING from circuits supplying motors is usually unsatisfactory. The greatest trouble is dimming of the lights caused by voltage drop when the motors are started. A rise above normal voltage is rather unusual. The trouble is probably caused by poor regulation at the plant, or a line that is too small for the connected load so that higher voltage has to be maintained.

If the voltage rises when the motors are cut off and soon goes back to normal, the cause is poor regulation at the plant. It may be corrected only by installing better regulators. If the voltage rises when the motors are cut off and remains high until they are again started, the trouble is obviously caused by excessive voltage required to overcome voltage drop. The remedy is to install a new line of sufficient capacity.

Insufficient transformer capacity or transformers of inherently poor regulation would have too much line loss and give the same results. Overloading is usually caused by additional machines being installed from time to time without increasing transformer or power line capacity. In either case the remedy is obvious. W. L. COTTON.

Electrical Department
Rock Island Railroad
Dalhart, Texas

WHERE power is bought the purchaser has no jurisdiction over the voltage, because it is usually the power company's job to deliver a specific voltage to the property and maintain this voltage within a small percentage.

I suggest that a thorough check of all main-line feeders be made to determine the load on each phase and see whether they are properly balanced. Check the power factor. Determine the full-load and no-load voltages at the point of entrance and at the end of the lines.

If the feeders are reasonably balanced, not overloaded, and the power factor is up, voltage regulation should be taken care of by the power company. When the test is to be made, ask the power company to have a representative present and make a joint test. Power companies are usually very willing to cooperate with a customer.

If some condition exists in the plant, such as a grounded motor or wiring, which would cause a heavy load, a considerable difference in voltage would probably be noticed and it might be sufficient to cause the voltage regulator to build up. When the overload is suddenly released a momentary high voltage might be encountered. I would be interested to know whether any jump in the power bills has been noticed since this trouble developed. L. F. MILLER.

Electrical Engineer
New York Trap Rock Corporation
Haverstraw, N. Y.

WHETHER the voltage drop takes place inside or outside the plant can be determined by placing a voltmeter across the lines where they enter it. If the voltage is constant at this point it will be obvious that the voltage variation takes place inside the plant. However, even though the voltage at this point is constant it may be too high at all times, as is indicated by the voltage rising to 260 or 270 volts when the load is decreased, which should be corrected by using a lower tap of the supply transformer.

Should the voltage variation take place outside the plant, it may be because the primary supply voltage to the transformer bank is not kept constant, as a result of the plant being remotely located.

If the plant power factor is low when the motor load is on and the transformer bank is fully loaded the regulation will be very poor, causing an appreciable voltage drop.

There may be no transformer bank close to the plant; so the voltage drop between the power company's bank and the plant may be excessive under load, causing the company to use a higher transformer tap in order to keep the voltage normal, and resulting in a volt-

age rise when part of the load is removed.

If the voltage variation takes place inside the plant the distribution system conductors probably are too small, causing an excessive drop in the lines, and replacement should be considered. This condition is bad, for it may result in burning out not only lamps but also motors, when the system is not sufficiently loaded to keep the voltage down. In addition to this risk, the motor efficiency and power factor will be lowered.

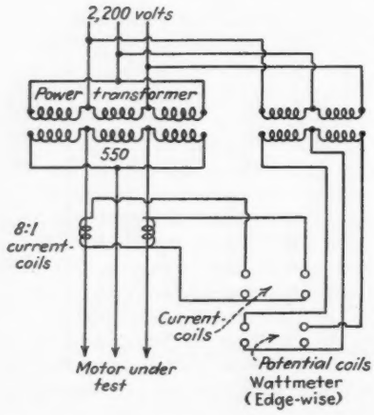
If low power factor is causing part of the trouble it might be raised by interchanging the squirrel-cage motors on different machines so that they operate nearer to their full-load rating. Power factor may also be increased by replacing some of the squirrel-cage motors with synchronous or synchronous-induction motors which operate at leading power factor, thereby helping to regulate the voltage and decrease the power loss in the line. A. G. VIOLA.

St. Louis, Mo.

■

What Is Wrong With These Connections?

In order to check our 550-volt motors with a wattmeter a spare G.E. indicating wattmeter was removed from the switchboard. This meter had a full-scale reading of 1,500 kw., and it was decided to replace the 80:1 current transformers



with others of 8:1 ratio, thus bringing the scale down to 150 kw. Potential coils suitable for use on the 550-volt circuit were not available; so as an experiment the meter was connected as shown in the diagram, using the 2,300-volt coils. The readings were very unsatisfactory, which I believe was due to the potential transformer being connected to the primary side of the transformer bank. Do other readers agree with me on this point? R.G.M.

Prince Rupert, B. C., Canada.

THERE is no reason why the connections shown should not give comparative results assuming, of course, that the indicating wattmeter is correctly connected. In the absence of information covering the capacity of the bank and the load on the motor only general comments can be given. Among the possibilities for error are:

1. Regulation of the bank
2. Losses in the bank
3. Differences in the power factor on the motor and line sides
4. Phase angle differences in the two sides
5. Difference caused by tap connections of the transformers

Of these No. 5 is probably the most serious. Although the potential transformer ratio is not given I assume that it is 2,200/550 or 4 to 1. If the main bank ratio, due to the arrangement of the taps is, say 2,090 to 550, or 3.6 to 1, the meter would probably read high. Neglecting the matter of transformer regulation, which is usually not important, the meter reading should be multiplied by $(3.6 \div 4)$. In general the tendency would be to give a higher reading under all conditions, owing to the higher voltage on the meter potential coils, this voltage being more nearly constant than the motor voltage, which would vary with the load.

Items 1 to 4 inclusive are usually not important with standard equipment.

It would be far better, particularly for purposes of comparison, to place the current transformers on the 2,200-volt side and from test data or from manufacturers' information make allowance for the transformer losses for each motor load. This method would require, of course, current transformers of lower ratio, having insulation suitable for the higher-voltage circuit.

C. O. VON DANNENBERG.

Altoona, Pa.

AS CONNECTED the meter should give a fairly accurate indication, provided that the power transformers are connected for the exact ratio assumed, not on high or low taps, and that proper account is taken of all ratios. If the current is measured on the 550-volt side it must be considered that the voltage has this value also; that is, that the potential transformer ratio is 5 to 1, and not 20 to 1.

If this meter were originally calibrated for a 1,500-kw. scale, using 20-to-1 potential and 80-to-1 current transformers it will read, as now connected and with 150-kw. scale, four times higher than it should. The current transformer for correct reading should have a ratio of 32 to 1; the nearest commercial ratio, 30 to 1, would give a reading approximately 6 per cent high.

Another factor to consider is the relative polarities of the power and potential transformers. If they are of opposite polarity the potential connections should be reversed at the meter.

Salt Lake City, Utah M. WOFFINDEN.

Must Tight Side of Belt Be on Bottom?

I have always understood that the slack side of a belt drive should be on top. In the case of some drives that are being rearranged it will be very difficult or impossible to have the tight side on the bottom, and I am wondering whether there will be any loss of efficiency or capacity if we operate them with the slack side on the bottom. These drives transmit from 3 to 15 hp. The distance between shafts is normal. Will the material from which the belt is made—leather, rubber, fabric—make any difference? B.G.A.

Chicago, Ill.

WHEN the tight side is on the bottom and the slack side on top the weight of the belt tends to increase the arc of contact, whereas with the slack side on the bottom the weight of the bottom side pulls it away from the pulley and decreases the arc of contact. The decrease in arc of contact is not serious if the belt is run under normal tension, but becomes troublesome if the belt stretches. Figs. 1 and 2 illustrate this point.

Centrifugal force also tends to decrease the arc of contact on a top-pull drive more than on a bottom pull. Consider a belt operating over pulley *B* in Fig. 1. Centrifugal force would make the belt resist wrapping around the pulley, whereas on pulley *A* the tension on the bottom side of the belt would help to overcome this force. On pulley *B* both the weight of the belt acting downward and the fact that the bottom side is slack would help centrifugal force to throw the belt away from the pulley, thus decreasing the arc of contact. Obviously, this condition would be worse if, as in Fig. 2, the belt were operating slack.

The transmission ability of a belt depends upon four factors:

1. The width of the belt
2. The coefficient of friction between the belting material and the pulley surface
3. The arc of contact between the belt and the pulley
4. The tension between the belt and the pulley

If a belt is of just sufficient capacity to handle a given drive and any one of these factors is reduced, obviously one of the others must be increased to compensate for it. That is, if the arc of contact is reduced materially it will be necessary to increase the tension, increase the width of the belt, or use a belt with a higher coefficient of friction. Increasing the width of the belt adds to its cost and frequently necessitates the use of wider pulleys. It is usually a simple matter to increase the tension on any drive, but doing so increases the load on both the belt and

the bearings, thereby decreasing their life. Of course, if the drive is overbelted in the first place a reasonable variation in arc of contact will not affect the efficiency.

For a top-pull drive it is best to use belting that is as flexible as possible, because a stiff belt will not bend readily around the pulley and will tend further to decrease the arc of contact. A flexible belt which hugs the pulley will always give greater arc of contact, regardless of whether the drive be top-pull or bottom-pull.

If B.G.A.'s drives are of normal center

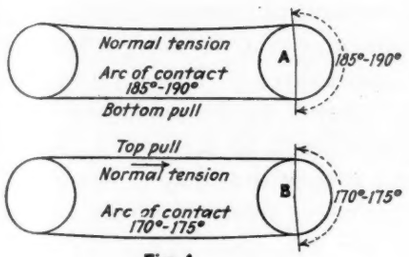


Fig. 1

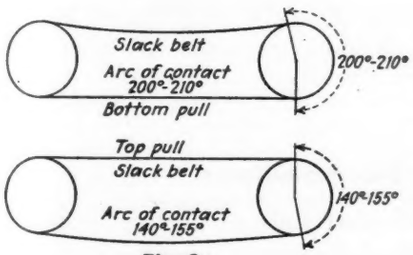


Fig. 2

Effect on arc of contact of operating tight and slack belts with top and bottom pull.

distance, as he states, and there is not too much difference in pulley diameters he need have no fear of getting good results. He will get the best results by using a flexible belting with a high coefficient of friction.

If there will be too much reduction in arc of contact he should allow for this in calculating the width of the belts. Correction factors that are generally used in calculating the width of belt required for a drive with less than 180-deg. arc of contact are:

Arc of Contact	*Factor*
170 deg.	1.05
160 deg.	1.11
150 deg.	1.17
140 deg.	1.24

After calculating the width of belt to transmit the horsepower at the required speed, assuming the arc of contact to be 180 deg., the width should be multiplied by the proper factor to determine the correct width of belt to transmit the power efficiently at the reduced arc of contact. V. W. WELLS.

Technical Department
E. F. Houghton & Company
Philadelphia, Pa.

Lubrication of Ball and Roller Bearings

Lubrication of 60 motors and generators fitted with ball or roller bearings is giving us trouble. These machines are rated from 1- to 250-hp. and are used on equipment ranging from gasoline-electric locomotives to small sump pumps. Careful reading of manufacturers' bulletins has failed to give me the answer to these questions: (1) How much lubricant should be kept in a ball bearing? (2) What kind of lubricant should be used? (3) How can I tell when the proper amount of lubricant is being used? We use light grease and in order to prevent it from creeping out along the shaft a small hole has been drilled in each bearing level with the bottom of the shaft. In spite of this precaution a great deal of trouble is caused by grease getting on the commutator and windings. How can I demonstrate to the oilers and operators when enough grease, but not too much, has been put in? J.R.C.

Peoria, Ill.

THROUGH tests of about twenty different kinds of greases we have found a brand known as Lancashire to be the most suitable for high speeds and temperatures.

When filling the housing it is best to take the cap off, clean everything thoroughly, put a little grease on the bearing itself, and fill the cap about one-third full. Too much grease will cause a bearing to heat.

For motors running at 3,600 r.p.m. on 24-hr. duty we use only the grease mentioned above. For lower speeds and lighter duty SKF grease is used. Other greases that can be recommended are: Roller Bearing Grease No. 2099, Standard Oil Company of New Jersey; Marfak No. 3, The Texas Company; Keystone No. 44, The Keystone Lubricating Company; and this company's Velox No. 3, in locations where water might get into a bearing.

We check the condition and amount of lubricant in all bearings every three to six months, depending on their duty.

F. G. BONN.

Electrical Superintendent
Hammond Cedar Company, Ltd.
Port Hammond, B. C., Canada

LUBRICATION of ball- and roller-bearing motors presents no difficulty if it is kept in mind that about 90 per cent of all trouble in such bearings is due to over-lubrication or a poor grade of lubricant.

My experience with ball-bearing motors has led to this servicing program:

Once a year all ball bearings are opened up and thoroughly washed with gasoline. It is best to use a spray gun since this will cut any dry, hardened grease adhering to the races and cages.

After they are thoroughly dry and clean the housings are packed not more than one-third full of special, ball bearing grease. It should be of the very highest grade. The manufacturers are usually glad to recommend the best grade to use.

The utmost cleanliness must be observed while the bearings are down. If bearings are properly treated in this manner they can safely run for a year under almost any conditions of service. This may seem too long to leave any bearing without examination, but I know of one type of ball-bearing motor (manufactured in Great Britain) which the makers advise opening up only once in three or four years. These motors are purposely not fitted with the customary filling plugs, so that no grease can be added.

If bearings are properly designed and packed with the correct amount of grease no trouble should be experienced with grease working along the shaft into the windings, but if too much lubricant is used the pressure set up in the housing will force the excess grease out through the tightest-fitting cover.

Recommendations as to the grade of grease required for exceptionally high ambient temperatures should be obtained from the makers. G. NOBLE.

Mountain Park, Alberta, Canada

BALL- OR roller-bearing motors or generators should be lubricated with a material that:

1. Protects the bearing from corrosion
2. Contains no corrosive agent
3. Does not harden or become gummy
4. Does not separate into its constituents (high melting point)
5. Does not produce excessive friction

The consistency of the grease should be such that the balls or rollers will not cut a channel through it, but it should not be so soft that it readily flows into their path, causing a higher operating temperature. Superla 2X or its equivalent should give satisfactory results with the machines operating in this plant.

Bearings should be about one-third full. Too much lubricant will cause excessive friction, heating, and leakage. The lubricant should not be put in with a high-pressure gun, but should be applied by hand when the bearing is exposed, or by means of grease cups.

If machines are in a hot location the lubricant may need to be renewed every two or three months, but under normal conditions once a year is often enough. However, it is advisable to make periodic inspections to determine the condition of the lubricant and need for renewal. This may be done by removing the bearing cap on the end opposite the pulley; it is usually safe to assume that if this bearing has sufficient lubricant and is in good condition the other bearing does not need attention.

St. Louis, Mo. A. G. VIOLA.

MAINTENANCE ENGINEERING

L. C. MORROW, Editor

AUGUST, 1932

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Electrical Watchdogs

JAGGED lines on a graphic instrument record may point an unexpected way to plant economies. Measure machine output; is it costing more than it should?

Never before have you been forced to scan details of equipment costs with so critical an eye. The depression has driven home the lesson that small items will, in the aggregate, amount to considerable savings.

Indicating and recording instruments are vital to such an efficiency program. Obviously, unless you measure a machine's performance, you cannot judge accurately whether it is giving you your money's worth. Proper records may lead to savings through a slight change in motor application, machine operation, or location.

A thousand places in the plant other than the main panelboard call for meters: Electricity usually is paid for on the basis of "peak load"; analyze the components that go to make up this peak by placing instruments right at your drives—perhaps your load can be more evenly distributed. Use power-factor meters to see whether you can save money in that direction. Determine the active and idle periods of machines by means of recording instruments.

A list like this could be extended indefinitely; one use will suggest another. Think it over. Instruments furnish a positive basis upon which to make decisions.

■

Help To Stop This Waste

IT HAS long harassed the designing and production engineers of industrial equipment to see their careful efforts to lower equipment costs nullified by the addition of a needlessly top heavy sales expense. In the case of many standard types of equipment requiring little engineering service, well planned drives have reduced sales expense to a reasonable figure, thus broadening the field of the equipment and saving money for the purchasers.

But, where the equipment must be tailored to the job, as is the case with most materials handling equipment, considerable engineering work must be done before a proposal can be made. Although this service is often advertised as "free" by the manufacturers it is well known that all sales expense must be absorbed in the price of the equipment. When, as frequently happens, ten or more manufacturers send their engineers to a plant to design and estimate one materials handling system, the amount of money wasted by the nine or more companies that do not get the job can readily be appreciated. These companies must charge this expense to the equipment that they are fortunate enough to sell in the future, thus adding to the cost of the equipment expense for which the purchasers receive nothing. Even more regrettable are the cases where the prospect buys nothing or decides to build the equipment himself, using one or a combination of the manufacturers' designs for which he has paid nothing.

■

No Admittance

ANY PLANT that fails to protect its buildings and grounds against intrusion is simply inviting the thief, the rioter, or the wanton destroyer of property to do his worst. Some of these gentry are with us always and it is ever good policy to guard against them. Now it is more necessary to do so than in ordinary times, because needs are greater, temptations more potent.

Watchmen are essential parts of any scheme of protection, but they cannot be everywhere at once. In most cases a sturdy fence must form one of the first defenses against invaders. Although not impregnable, a strong fence cannot be shot or slugged and it interposes a barrier that is not easily overcome.

Floodlighting of grounds and buildings is another effective measure deserving of wider use. Installation of a special type of searchlight in a Texas cement plant recently put an end to a series of thefts of valuable property. The searchlight was placed in a tower so that its beams can be directed to any part of the property, and is operated by a watchman armed with a rifle.

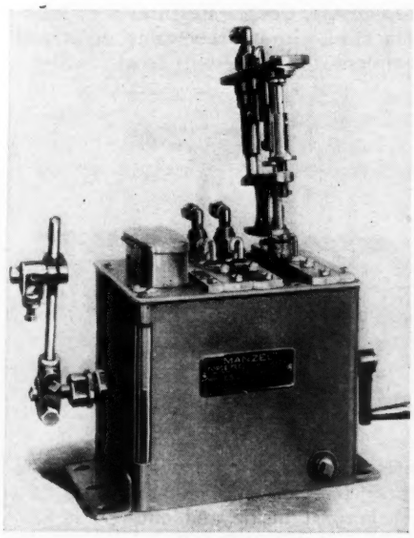
Many other schemes and devices are available to meet specific problems. Obviously, determination of what is needed for adequate protection, and prompt action in installing it, constitute highly commendable procedure.

EQUIPMENT NEWS

Manzel Model 25 Lubricator

For automatic lubrication of the bearings of industrial machinery the Model 25 automatic force feed lubricator has been developed by Manzel Brothers Company, 309 Babcock St., Buffalo, N. Y. An independent oil line feeds each point to be lubricated. The lubricator is placed on the frame of the machine on which it is to be used, and connected to some movable part. It can be driven either by a reciprocating or rotary motion, and the feed can be adjusted according to the amount of oil required at each bearing. After the reservoir is filled with oil and the individual feeds adjusted no further attention is required except to replenish the oil supply when necessary.

The device consists of a tank in which are placed a number of individual pumping units. Each unit is, in itself, a small double plunger pump which can be adjusted independently. All working parts are completely inclosed in the reservoir. Any pumping unit may be taken from the reservoir for examination, repairs, or replacement without stopping the operation of the lubricator or the equipment on which it is installed. The lubricators are suitable for operation against pressures up to 1,000 lb. per sq.in., with the feed of each unit adjustable from a minimum of one-tenth of a drop per stroke of the



lubricator to a maximum of 13 drops with every stroke.

They can be supplied with from 1 to 30 feeds, with rotary or ratchet drive, and with different reservoir capacities. For high speed machines requiring very small amounts of oil, lubricators with special reduced drives can be furnished, the drive reduction varying from 37½ to 1 up to 1,600 to 1. For extremely slow moving machinery direct acting lubricators, which deliver oil at every stroke of the driving lever, can be supplied.

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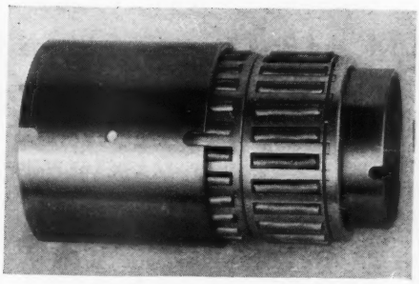
Bantam Roller Bearing

Designed especially for cylinders of printing presses but applicable to other types of machinery is a roller bearing announced by the Bantam Ball Bearing



Company, South Bend, Ind. One cage has 23 rollers and the other cage 24 rollers, giving a "hunting tooth" effect toward the elimination of synchronized vibration of cylinders at high speed—each cage operating independently of the other. Rollers and races have a lapped finish and are made of high-carbon chrome steel, hardened and heat-treated.

■

Bastian-Blessing Welding Rods and Electrodes

Under the trade name of "Regorod," The Bastian-Blessing Company, 240 East Ontario St., Chicago, Ill., has introduced a line of welding rods and electrodes that includes every type and size of rod in common usage.

■

Kennedy Valves

Rising stem gate valves for 125-lb. steam pressure and 175-lb. water pressure have been added to the line made by The Kennedy Valve Manufacturing Company, Elmira, N. Y. The solid wedge disk mechanism is the same as that used for the standard, stationary stem, bronze gate valve.

A flexible connection is provided between the disk and the stem so that the stem will not bind or spring when the valve is closed. The stem is made of a bronze composition.

The bonnet hexagon has been made extra-large to prevent distortion when a wrench is applied for installing or disconnecting. Additional features of this design are the deep stuffing box with gland and square-section, molded packing rings, the non-heating, malleable iron handwheel which is secured to the stem by a nut, and the heavy, wide pipe and hexagons.

■

Amthor Hand Tachometer

A direct reading hand tachometer, "Type 350," for testing machine speeds has been announced by the Amthor Testing Instrument Company, 309 Johnson St., Brooklyn, N. Y. It incorporates the feature of automatic fixed reading, whereby the speed reading is automatically fixed on the dial after each time the instrument is used.

Since with this feature it is no longer necessary to keep the eyes focused on the dial, the tachometer can be used in inaccessible places where it is awkward to hold and read the instrument at the same time.

The dial is graduated to read directly in revolutions per minute but the in-

strument is fully equipped so that all "feet per minute" surface and belt speeds can be taken. The tachometer has four speed ranges, each of which is separately read over the entire circumference of the dial. Each is constructed with a balanced cross pendulum gover-

nor movement, and is hand calibrated. Various ranges can be had to measure directly speeds at high as 12,000 revolutions per minute.

■

Lincoln Electrode Holder

An electrode holder stand known as the "Power Saver" which shuts down the welding unit one minute after the holder is placed on the stand and instantly starts the welder when the holder is removed, has been announced by The Lincoln Electric Company, Cleveland, Ohio.

It is claimed that the automatic start-and-stop feature of this device effects a decided saving in power consumption. When the hook is depressed by the weight of the holder it activates a timing device which, at the end of one minute, disconnects the welder from the

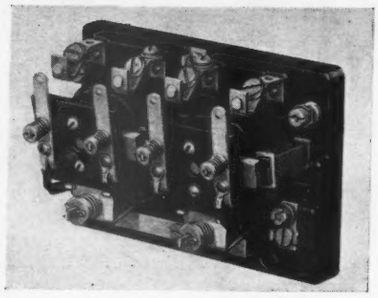
power supply line. When the holder is removed from the hook the welder starts automatically.

The stand is of arc welded steel construction. Holder hooks can be raised or lowered on the upright member to suit the convenience of the operator. Fifteen feet of rubber-covered, two-conductor cable is provided with the stand. The stand can be used whenever the welding equipment is provided with an automatic motor starter having two-wire pilot control.

■

Square D A.C. Reversing Contactor

Industrial Controller Division, Square D Company, Milwaukee, Wis., has introduced an a.c. reversing contactor, known as Class 8711, Type K. It is of small dimensions and particularly



adapted to small hoist, dumb waiter, window, and door control. Contactors are mounted on a porcelain base, are mechanically interlocked, and have silver-to-silver contacts. Maximum rating is ¾ hp., single- or three-phase. Dimensions are 6 in. wide, 4 in. high, and 3¼ in. deep.

■

Jarvis and Biax Companies Merge

Announcement has been made of the consolidation of the Charles L. Jarvis Company, Gildersleeve, Conn., manufacturers of tapping devices, quick-change chucks, stud setters, and screwdrivers, and the Biax Flexible Shaft Company, 22-14 40th Ave., Long Island City, N. Y. The latter company produces flexible shafting and flexible shaft machinery. The Biax plant has been moved to Gildersleeve, Conn., but a service and sales department will be maintained at the Long Island City address.

■

B-L Rectifiers

Type "F" rectifiers for relays, electromagnetic counters, industrial control devices, and other instruments which require relatively small amounts of d.c. power, have been introduced by the B-L Electric Manufacturing Company, 19th & Washington Aves., St. Louis, Mo. These units are single stack, full wave rectifiers. They are assembled on a ¼-in. bolt, and the maximum diameter of the disks used in their construction is ⅞-in. The connections to the unit are made by means of tinned soldering lugs.

■

Borden "Beaver" Power Adapter

A worm-driven die stock using interchangeable die heads to thread all sizes and kinds of pipe from ½ to 2 in., has been announced by The Borden Company, Warren, Ohio. The device, called the "Beaver power adapter," is operated by a ¾-in. heavy-duty electric drill. A compressed air drill may be used if desired. The adapter is made of aluminum alloy and weighs 17½ lb. A self centering chuck at the rear holds it firmly on the pipe and double-ended drive enables the cutting of right or left hand threads, or backing-off by power. A driving socket to fit electric or air drill chucks is supplied with each adapter.

■

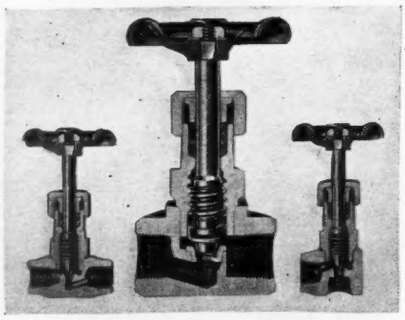
General Electric Outdoor Switchgear

Moderate duty metal-clad switchgear using oil circuit breakers of oil-blast construction has been applied to outdoor service by the General Electric Company, Schenectady, N. Y. This equipment includes a standard indoor metal-clad frame, instrument, transformer, and bus compartments, and the standard removable oil circuit breaker unit. Incoming leads enter from above and the feeder cables leave from below. A strip space heater keeps condensation at a minimum. Units may be elevated by a manual operating mechanism, or by means of a socket which can be placed in a power drill. The housing is of rust-resisting metal and the doors are furnished with visors and curtains to protect workmen during inclement weather.

■

Reading-Pratt & Cady Bar Stock Valves

Globe valves in ¾ and 1 in. sizes have been announced as an addition to its regular line of bar stock valves, by the Reading-Pratt & Cady Co., Inc., Bridgeport, Conn. Features are: stainless steel, slip-on renewable disks and stainless-steel screw-in seats. Stems



are designed and treated for temperature service. All other parts are Parkerized inside and out.

■

Wagner Capacitor Motors

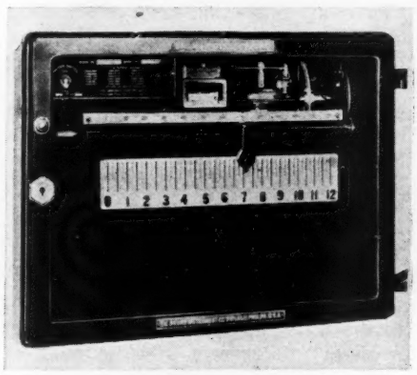
Supplementing its regular line of single-phase motors, Wagner Electric Corporation, 6412 Plymouth Ave., St. Louis, Mo., offers a line of capacitor

motors, known as Type RZH. They are condenser-start, condenser-run, split-phase motors, the condenser capacity varied from start to run by means of a switch and an auto-transformer. In appearance they differ from other motors made by this company in that a box is mounted as an integral part on the top of the motor, to accommodate the condenser and auto-transformer. The motors are available as rigid-mounted or rubber-mounted units, drip-proof and totally-inclosed.

■

Brown Indicating Potentiometer

An indicating potentiometer of the self-balancing type is the latest addition to the line of potentiometers made by The Brown Instrument Company, Philadelphia, Pa. Among the design features of these potentiometers are a 40-in. slide wire, positive spiral shaft drive, non-slip clutch, a secondary pointer that definitely fixes the size of



step in moving the slide-wire contact, and an interchangeable case for universal mounting. The mechanism can be swung out of the case for inspection without interfering with the operation. Mercury-in-glass switches are used in control models.

As a pyrometer this instrument can be supplied for any range from 0 to 100 deg. F. up to 0 to 3,000 deg. F. Models for automatically controlling as well as indicating temperatures are also available.

■

Hills-McCanna Centrifugal Pumps

Shaft and impeller alignment is secured by ball bearings that carry the load in any direction, in centrifugal pumps for handling chemicals, liquid foodstuffs, and other materials which have been announced by Hills-McCanna Company, 2349 Nelson St., Chicago, Ill. This construction is claimed to lengthen the life of the pump, reduce friction, and permit unusually close limits in fitting the impeller in the housing.

The stuffing box is of the split-screw, gland type. There is no bearing back of the packing, which eliminates the possibility of lubricant entering the pump. All parts that come in contact with the liquid can be furnished in any machinable ferrous or non-ferrous alloy.

Inboard and outboard heads are removable, a feature that facilitates replacement of heads and impeller when corrosive liquids are being handled.

Pumps can be supplied with or without motor drive.

■

Lincoln "Shield-Arc" Welder

Uniform welding current is one of the features claimed for the welder announced by The Lincoln Electric Company, Cleveland, Ohio. Reducing the rapid fluctuations in the usual welding current is said to permit the use of a higher average current, which results in increased speed of welding. The welder is rated at 40 volts, instead of the former 25, giving a 60 per cent greater kilowatt rating. This voltage is desirable for use with the Shielded Arc electrodes recently developed by the same company.

Due to the design the necessity for a stabilizer or kick transformer has been eliminated. The welder is equipped with dual-voltage control, which permits independent regulation of current and voltage, and a reversible-voltage control for welding with reversed polarity. A center-reading volt-ammeter on the control panel indicates whether the machine is operating with positive or negative polarity.

These welders are built in a.c. and d.c. motor-driven types of 300-, 400- and 600-amp. ratings.

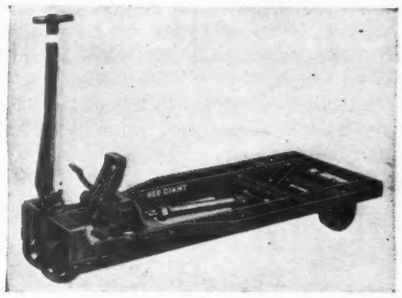
■

Goodrich "Fire King" Welding Hose

Development of a welding hose, named "Fire King," designed for a high bursting resistance when subjected to contact with molten steel, has been announced by the B. F. Goodrich Company, Akron, Ohio. The maximum length of the hose is 50 ft. The rubber is compounded especially for heat resistance. The inner plies are wrapped fabric, and the outside ply consists of braided asbestos yarn. The rubber cover is $\frac{3}{32}$ in. thick. The hose is stocked in the $\frac{1}{4}$-, $\frac{5}{16}$-, and $\frac{3}{8}$-in. sizes, in 50-ft. lengths, and in both red and green colors.

Revolvator Hand Lift Truck

Model "H," "Red Giant," double-stroke, hand lift truck is the latest addition to the line made by The Revolvator



Company, 336 Garfield Ave., Jersey City, N. J. This model has but one more moving part and will lift 2½ in. with half as much effort as required with the single stroke machine. Capacity ranges from 2,500 to 5,000 lb. Two platform widths are available: 18 in. wide, with lengths from 30 to 54 in.; and 26½ in. wide with lengths from 36 to 72 in. Steel is used throughout, with arc welded members.

Roller bearings and lubricating system are standard equipment.

■

Lewis-Shepard Lift Truck

The Lewis-Shepard Company, 125 Walnut St., Watertown Station, Boston, Mass., has announced a single-lift truck designated as the Gold Flash.

Head room has been reduced and among other features is a new design of release check with large excess of oil capacity for controlling lowering of the load. Construction is such that, when lowering, the load travels forward and downward at the same time. When in the load-raising position the handle is always connected to the load, so that the operator cannot pull on an empty handle and run the risk of falling backward.

These lift trucks are available in capacities up to 5,000 lb., in widths of 17½ in. or 24 in., and designed for lifts of 1⅝ in. or 2¼ inches.

■

Porter-Cable-Hutchinson Electric Hand Saw

Porter-Cable-Hutchinson Corporation, Syracuse, N. Y., has announced a hand power saw designated as type K-88. It weighs 18 lb., is powered with a 1-hp. a.c. and d.c. motor, and is designed to drive an 8-in. saw blade at 4,500 r.p.m. while cutting. If desired a 5-in. dado cutter, giving a maximum depth of cut of 1⅞ in., can be mounted on the shaft. Extra-long jackshafts

can be supplied for mounting wide dadoes and special three-lipped cutters.

The saw can be adjusted for depth and angularity of cut by a thumbscrew. Cuts can be made at any angle up to 45 deg. The pistol grip handle contains the switch, which must be held in while the saw is in operation. Saw blades are fully protected, even when cutting at an angle, by a two-piece guard. Practically all exterior parts of the saw are made of polished aluminum or duralumin.

Ability to cross-cut 2 in. hard pine at the rate of 1 ft. in 2 sec., and rip 1 ft. a second, is claimed.

■

Smith Two-Speed Reducers

A two-speed speed reducer has been placed on the market by Winfield H. Smith, Inc., Springville, Erie County, N. Y. It can be furnished with reduction ratios ranging from 4 to 1 to 150 to 1.

A hardened steel worm on the high-speed shaft drives a special-alloy bronze worm gear mounted on the intermediate shaft, which also carries two spur gears that are in constant mesh with two spur gears on the slow-speed shaft. Control of speed is obtained by means of a clutch that engages with one of the gears on the slow-speed shaft and is actuated by a yoke arm extending through the top of the reducer and carrying a shifting arm. The unit can be shifted from slow speed to high speed or to the neutral position while operating under full load.

■

Nutting Industrial Truck Tires

"Free Wheeling" rubber tires for industrial trucks, trailers, and casters have been announced by the Nutting Truck Company, Faribault, Minn. Tires are made of a hard rubber base impregnated with cord fabric, the same construction as that employed in the carcass of a pneumatic automobile tire. Many sizes to fit practically all existing two- and four-wheel trucks, trailers, casters, and lift trucks are available.

Electric Controller Master Switch

Announcement of a master switch known as type NX has been made by The Electric Controller & Manufacturing Company, 2696 East 79th St., Cleveland, Ohio. It is designed to handle the control circuits of a magnetic controller where not more than three points of speed control in either direction are required.

Applications for which it is particularly adapted include roll tables and other steel mill drives, bridge and trolley motions of small cranes, and small hoists equipped with the Wright dynamic lowering circuit magnetic controller.

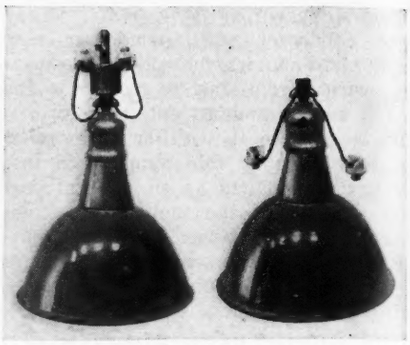
Features of the switch are: ball bearings of the combined radial and thrust type; renewable contact segments; contact fingers fitted with alloy tips; dead blocks made of wear-resistant material, which fill the spaces between contact segments. All wearing parts are designed for replacement from the front. . The switch is inclosed by a steel cover and has a Lynite aluminum frame. It may be mounted in the upright or inverted position, and the operating lever handle may be mounted vertically or horizontally.

■

Thompson Lamp Lowering Hanger

Attention has been called by The Thompson Electric Company, 1438 West Ninth St., Cleveland, Ohio, to important changes in its lamp lowering hangers. In the new design each contact member has only one porcelain block, instead of two, and all of the parts can be held in one hand while the assembling is done with the other.

The lower contact elements are wired to the reflector or lamp fixture instead of to the bottom member of the hanger, making it possible for one reflector to be substituted for another without any rewiring. By lifting the contact members out of the sockets and unscrewing the lamp attachment from the base of the hanger the reflector can be disconnected and removed to a central point for repairs. To install another reflector



it is screwed into the base of the hanger and the contact elements dropped into the sockets.

Advantages claimed are greater simplicity in wiring and ease with which lamps can be replaced or repairs made.

■

U. S. Electric Drill

A drill known as the ¼-in. Midget has been added to its line by The U. S. Electrical Tool Company, 2475 West Sixth St., Cincinnati, Ohio. Designed for light-duty work and where close-quarter operation is necessary, this drill weighs only 3½ lb. and is 8 in. long without the handle, which is removable.

The body is of aluminum. Gears are of the double-reduction type, made of hardened chrome-manganese steel, operating in a grease-tight compartment. The drill is powered with a universal motor, and is furnished with a ¼-in. screw-back chuck. The handle is bolted to the body, but can be removed when necessary to operate in close quarters.

■

Rawlplug "Lok-Crowners"

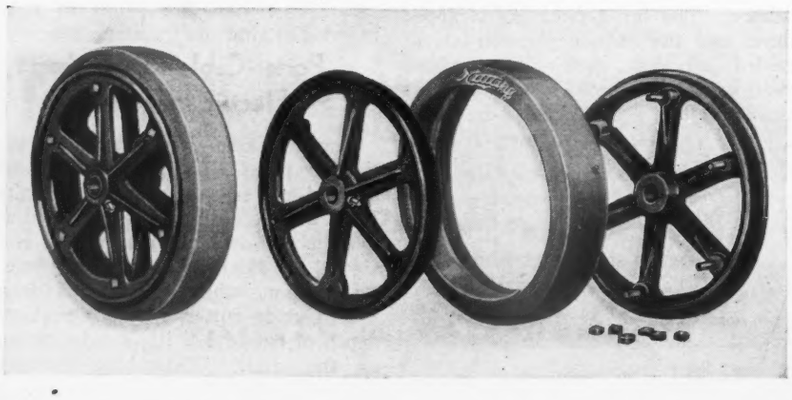
A lock washer and a metal cap named the "Lok-Crowner" which completely conceals and seals bolt or screw heads or nuts has been developed by the Rawlplug Company, 98 Lafayette St., New York, N. Y. The lock washer is made of spring steel to fit all size bolts and screws, has a four point locking arrangement, and is cup-shaped with projecting prongs which engage and hold the decorative cap.

Rustproof caps are either drawn metal or molded bakelite for installations requiring electrical insulation. Caps are furnished either plain or embossed, and cover the lock washer, preventing rust or stain.

■

Westinghouse "FlexArc"

Gas-engine-driven welders of 300- and 400-amp. ratings have been announced by the Westinghouse Electric



& Manufacturing Company, East Pittsburgh, Pa. They embody the following features: full canopy protection from the weather; easily accessible controls; dependable power unit; transformer-type reactance to prevent current surges and sticking of electrodes.

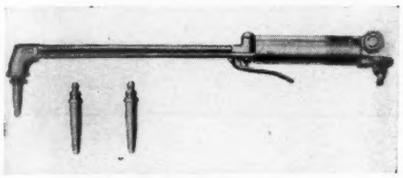
Standard units are equipped with large, 6-in.-rim, steel-tired wheels. Smaller, shop-type wheels, as well as solid-rubber-tired wheels, can be furnished when desired.

Oversize exciters can be furnished for operating small portable tools, such as drills, grinders, buffers, or lights.

■

Milburn Cutting and Welding Torch

Tips, Inc., 515 Cathedral Street, Baltimore, Md., announces that it has been appointed exclusive distributors of the Type NVM cutting and welding torch, manufactured by The Alexander Milburn Company, Baltimore, Md.



Valves and base are of forged bronze. Replacements can be made without disassembling the torch. The 90-deg. head is designed to take standard Type NV conical seated tips.

■

General Electric Splash-Proof Induction Motors

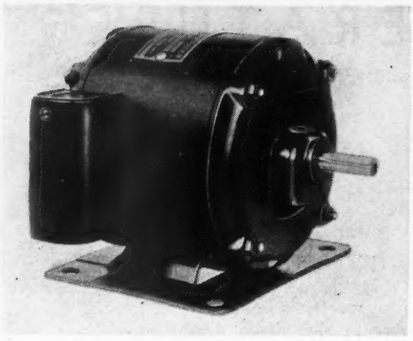
A line of splash-proof induction motors has been announced by the General Electric Company, Schenectady, N. Y. End shields have a top half solid to exclude dripping water and liquids. Cooling air enters through ventilating openings in the bottom half. A baffle prevents the entrance of splash into the windings.

Protection against the entrance of liquids into the frame is secured by a one-piece cover fitted to the motor frame. Ventilating air is circulated over the end windings across the motor frame and out through louvres in the protective cover. A water-tight conduit box protects the motor leads.

■

Wagner Split-Phase Motors

Split-phase motors, Types 44RB and 56RB, are announced by the Wagner Electric Corporation, 6412 Plymouth



Ave., St. Louis, Mo. They are available in 1/30 to ¼ hp., 1,725 and 1,140 r.p.m., all cycles. Design includes drip-proof endplates, wool-yarn lubrication, and a conduit box adjustable in four positions. The illustration shows type 44RB.

■

Snell Metal Polish

Foster D. Snell, Inc., Brooklyn, N. Y., has developed a non-flammable metal polish in powder form, which produces a stable suspension when mixed with water.

■

Marsh Type "R" Bonnet Assembly

Type "R" radiator valve bonnet assembly of the James P. Marsh Corporation, 2073 Southport Ave., Chicago, Ill., is a replacement unit for any standard make or size of packed or packless inlet valve. Installation consists of inserting the unit in the old valve body and screwing into place.

The valve assembly is operated by the valve stem which is threaded into the disk holder nut. Rotation of the valve handle causes the disk to be raised or lowered in the body of the valve, thus regulating the flow of steam into the radiator. The packless sealing arrangement of this valve consists of two sets of thin metal disks.

■

Oxweld Type W-22 Welding Blowpipe

The Linde Air Products Company, 30 E. 42nd St., New York, N. Y., announces a welding blowpipe designated as Type W-22, and covering the same range of work as the Type W-17 welding blowpipe.

The acetylene valve is located on the left side of the front of the handle where the operator's right thumb can conveniently regulate it. The oxygen valve is located on the underside of the handle. This arrangement makes it unnecessary for the operator to use his left hand, which is holding the welding rod in adjusting the valves.

A feature is the long acetylene passageway between acetylene valve and injector which minimizes the possibility of flashback. Another feature is the ball-type acetylene valve, consisting essentially of a stainless steel sphere hardened and ground, which gives a narrow line of contact and eliminates carbon deposition difficulties.

■

Allen-Bradley Hand-Operated A. C. Starting Switch

A manually operated switch that will start and stop small a.c. motors and give overload production has been developed by the Allen-Bradley Company, 1311 South First Street, Milwaukee, Wisconsin. The switch, known as Bulletin 609 switch, has two overload relays. Tripping of either relay opens the contactor and disconnects the motor from the line. Either relay, after tripping, can be reset without opening the switch cabinet. The switch is closed and opened by means of two operating buttons extending through the cabinet cover.

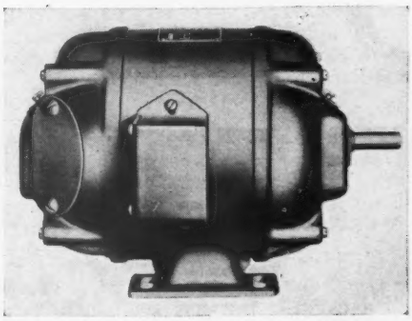
There are five parts—a terminal block, a movable contactor arm, the operating button mechanism and the two overload relays. Double-break silver-to-silver contacts eliminate the need for flexible connectors and reduce maintenance of the contacts.

Size 1 has three poles, and will handle self-starting single-phase motors up to 1 hp., 110 volts, and 2 hp., 220 volts, and polyphase motors up to 2 hp., at 220, 440 and 550 volts. Size 2 has 3 and 4 poles, and is rated at 5 hp., 220 volts, and 7½ hp., 440 and 550 volts, for 2 and 3 phase motors.

■

Century Brush-Riding Motors

Century Electric Company, St. Louis, Mo., has developed a line of brush-riding, single-phase repulsion-start, induction motors, intended primarily for those applications where quiet operation is not required. The motors are not intended to replace the line of brush-lifting motors.



TRADE LITERATURE

For copies, address the manufacturers concerned

■

(216) BRAZING ALLOY—Bulletin No. 7, properties and typical uses of "Sil-Fos" brazing alloy.—Handy & Harman, 57 William St., New York, N. Y.

(217) CIRCUIT BREAKERS—Catalog 2246, 76 pages, operation, construction and application of "Nofuse" De-Ion circuit breakers.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(218) EXHAUST FANS—Bulletin No. 166, 12 pages, mechanical and engineering features of Duriron acid resisting exhaust fans. Dimension drawings, discharge arrangements and capacity tables are included.—The Duriron Company, Incorporated, Dayton, Ohio.

(219) CONTROLLERS—Bulletin No. 1010, features of the company's valveless automatic controllers for atmosphere and temperature in oil burning furnaces.—Johnston Manufacturing Company, 2825 E. Hennepin Ave., Minneapolis, Minn.

(220) AIR FILTERS—Form 502, 26 pages, "American Air Filters in Industry." The bulletin deals with the relation of filtered air to a number of industrial problems such as cooling electrical equipment and the protection of engines and compressors.—American Air Filter Company, Incorporated, 215 Central Ave., Louisville, Ky.

(221) MOTOR—Bulletin No. 210, 20 pages, details in design, characteristics, and construction of the Noel polyphase capacitor motor.—The Ideal Electric and Manufacturing Company, Mansfield, Ohio.

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(225) MOTORPUMPS—Folder, "The Cameron Motorpump," ½- to 25-hp., open type, totally inclosed, or explosion-proof motors, 5- to 800-gal. per min. capacities.—Ingersoll-Rand Company, Phillipsburg, N. J.

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(227) CONTROL SYSTEM—Circular 1948, 8 pages, operation and construction of the "Polaricode" supervisory control system.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(228) RHEOSTATS—Bulletin 1330, 1932 types "Jagabi" rheostats, specifications and price tables.—James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

(229) MOTOR—Folder, construction features of the "Linc-Weld" Type E induction motor.—The Lincoln Electric Company, Cleveland, Ohio.

(230) VALVES—Catalog, 8 pages, describing the company's line of bar stock valves.—The Reading-Pratt & Cady Company, Inc., Bridgeport, Conn.

(231) POWER TRANSMISSION—Bulletin, "The Lewellen Series 100 Fully Enclosed Transmissions."—The Lewellen Manufacturing Company, Columbus, Ind.

(232) ARC WELDING—Bulletin, "The Novice Understands and the Expert Appreciates," operating advantages of the P&H—Hansen arc welder. Models ranging from 100- to 800-amp. capacity are pictured and described.—Harnischfeger Corporation, 4400 W. National Ave., Milwaukee, Wis.

(233) MOTORS—Bulletin 111, 8 pages, principal features of Type AA, induction, squirrel-cage motors for two- and three-phase, a.c. circuits.—Reliance Electric & Engineering Company, Ivanhoe Rd., Cleveland, Ohio.

(234) RELAYS—Folder GEA-1583, importance of relays in the design of systems, applications of specific types manufactured by the company.—General Electric Company, Schenectady, N. Y.

(235) CLUTCHES—Bulletin, 16 pages, installation and use of magnetic clutches for special and general power transmission applications. Single disk, multiple disk, and serrated disk types are described; installation diagrams and tables of performance are included.—Dings Magnetic Separator Company, Milwaukee, Wis.

(236) CONDENSERS—Bulletin No. 411, 8 pages, description of jet condensers and auxiliaries for vacuum processes, to be marketed by Byer Engineering Associates, 75 West St., New York, N. Y.—Pennsylvania Pump and Compressor Company, Easton, Pa.

(237) BUCKET TRAP—Bulletin S-11, operation of Type "A" inverted bucket trap and other new power plant equipment.—The Swartwout Company, 18511 Euclid Ave., Cleveland, Ohio.

Contents for August, 1932

Copyright, 1932, by McGraw-Hill Publishing Company, Inc. - - - Vol. 90, No. 8

Uses and Possibilities of Mercury Arc Rectifiers. . . . . A. L. ATHERTON 313

Individual and Group Drives. . . . . ROBERT DRAKE 317

For Plant Diagnoses—Electrical Instruments. . . . . G. A. VAN BRUNT 322

Maintenance Order Systems—Part VIII. . . . . G. I. ROSS 324

Profit Painting. 326

Industrial Unit Heaters. . . . . CARL HEYEL 328

Maint-o-Graphs. 331

Questions and Answers. 335

Editorials. 338

Equipment News and Trade Literature. 339

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